Western Region Saltwater Dive Workshop
Channel Islands National Park
August, 1985

DOCUMENTING THE REMAINS OF SHIPWRECKED VESSELS: NOTES ON SHIP TYPES AND CONSTRUCTION TECHNIQUES

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SUGGESTED BIBLIOGRAPHY

These books are generally available in libraries or are still in print.

Abell, Sir Westcott, The Shipwright's Trade (London: Conway Maritime Press, 1948, rep. 1981)

An excellent survey of naval architectural theory and practice from ancient times to modern (post Second World War) shipbuilding.

Adkins, Jan, Wooden Ship (Boston: Houghton Mifflin Company, 1978).

An simply written but accurate, illustrated discussion of the construction of a wooden whaling ship in 1870.

Chapelle, Howard I., The History of American Sailing Ships (New York: W.W. Norton, 1935, repr. Bonanza Books, n.d.)

Excellent discussion of various types of American sailing craft, ranging from schooners to ocean-going ships. Illustrated with plans, photographs, and drawings.

Desmond, Charles, Wooden Ship-Building (New York: Rudder Publishing Company, 1919 repr. Vestal Press Ltd. 1984)

Written to aid in the construction of wooden vessels during the First World War, an excellent, photograph illustrated treatise on the construction of wooden hulled steamships and sailing craft. Documents methods of fastening, etc., many of which date to the 18th and 19th centuries.

Paasch, Captain H., Illustrated Marine Encyclopedia (Antwerp: Rattincxx Freres, 1890 repr. Argus Books, 1977)

Encyclopedia with well-done plates showing wood, iron, and steel shipbuilding, anchors, equipment, rigging. Particularly good for vessels of mid to late 19th century construction.

Suggested format for recording shipwreck sites (primarily wooden hulls)

GENERAL SIZE OF THE VESSEL;

Length

Breadth: divide into equal increments to obtain

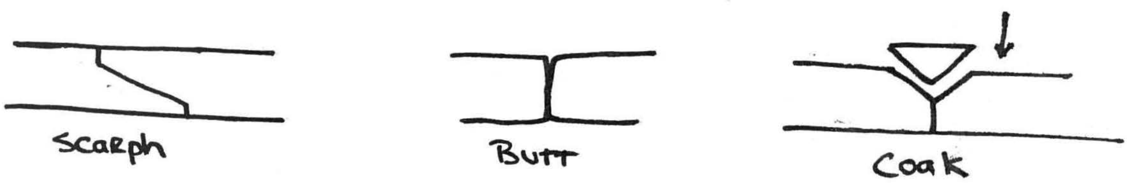
FRAMES:

Number of Frames

Spacing: If single frame, place tacks in middle of each frame and measure. If double frames, measure between frames to between frames. Try and measure frames at the midships portion of the vessel and measure at least six frames or sets of frames.

Compass timber or sawn?

Joints: scarphed, butt, coaks?



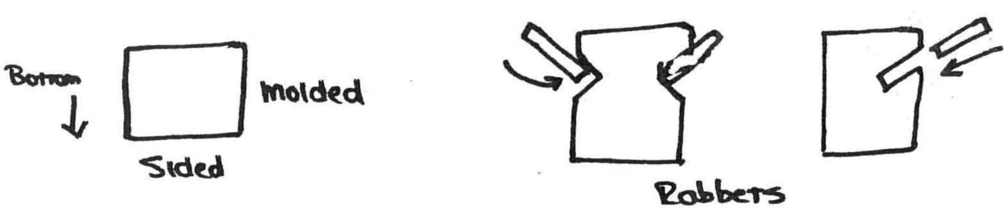
KEEL:

Sided and Molded Dimensions

Scarph Joints

Rabbets

False Keel and Shoe



STEM AND STERN: How many pieces make up the stem and stern?

How stem and stern meet the keel

Rabbets in stem and sternposts

PLANKING:

Widths of planks from keel or keelson out

Length of planks

How are the planks fastened to the frames?

- Spikes: measure and identify. Are they counterset?
- Drifts and bolts: measure and identify. Clinch rings?
- Treenails: measure and identify. Hand lathed or turned? Wedge?

Strakes: identify elevational differences

Sheathing: Identify type (wood, copper, yellow metal) Undercoat--tar, felt, hair, etc.?

Paint: inside and outside hull, color.

RIGGING:

Keelson: Mast steps? Mast partners?

Dimensions of keelson, sided and molded

Mast diameter

Chainplates: type, spacing

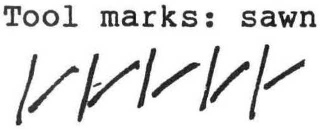
Rigging: type (wire, manila, hemp)

MISCELLANEOUS:

Windlass? Capstan?

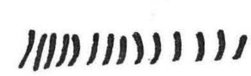
Pump: type, materials used, diameter, how fitted into vessel, sump, placement.

Tool marks: sawn



saw marks (pit saw)

trimming adze



trimming adze marks

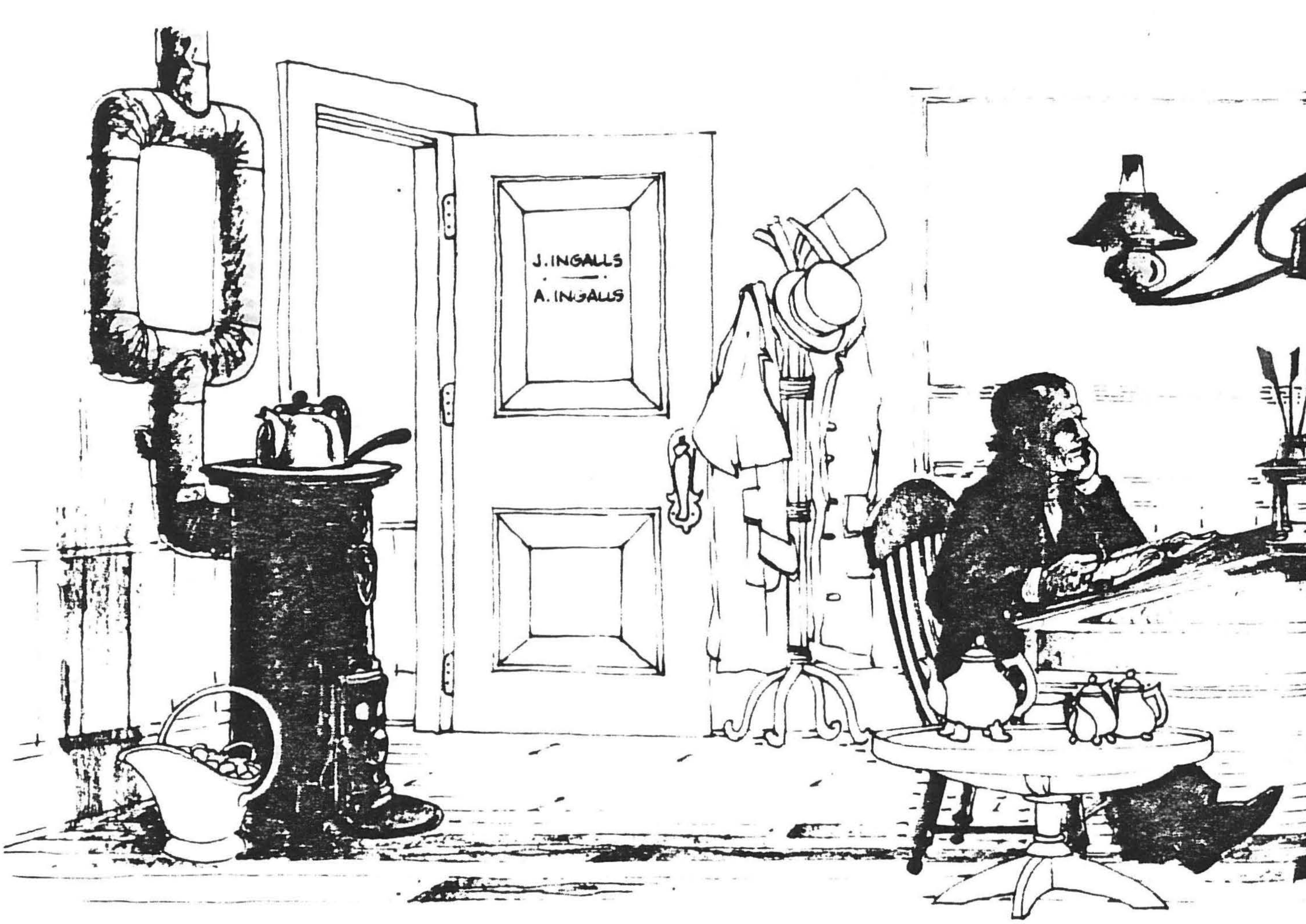
IRON OR STEEL HULLED VESSELS: Special considerations include the use of wood with metal (composite construction), the use of rivets vs. welding, and steam propulsion machinery.

HANDOUTS: EACH PACKET CONTAINS HANDOUTS WHICH ILLUSTRATE VESSEL TYPES, CONSTRUCTION, EQUIPMENT, AND MACHINERY.

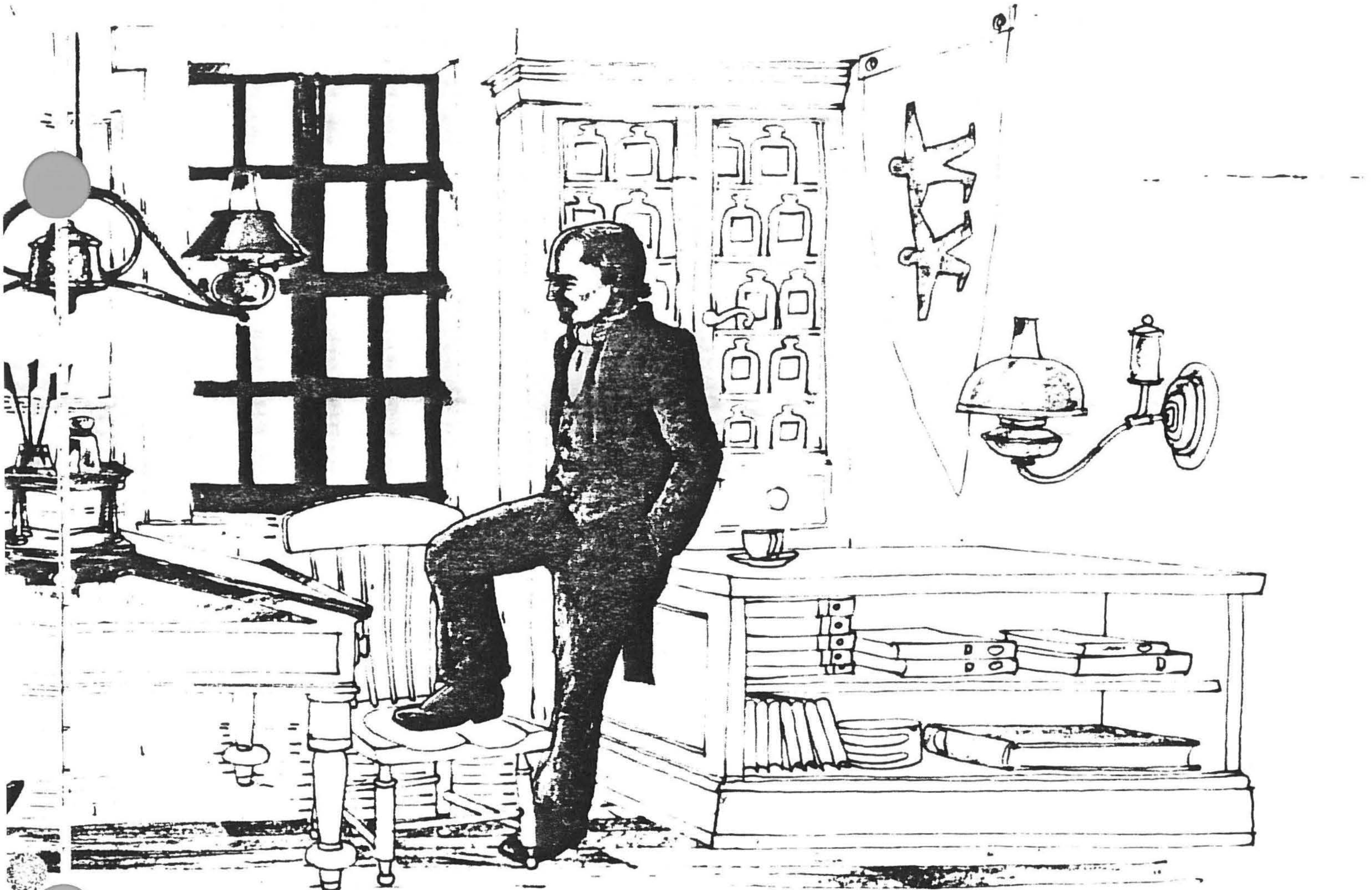
WOODEN SHIP

written, designed, and illustrated by
Jan Adkins

Houghton Mifflin Company, Boston, Massachusetts, 1978



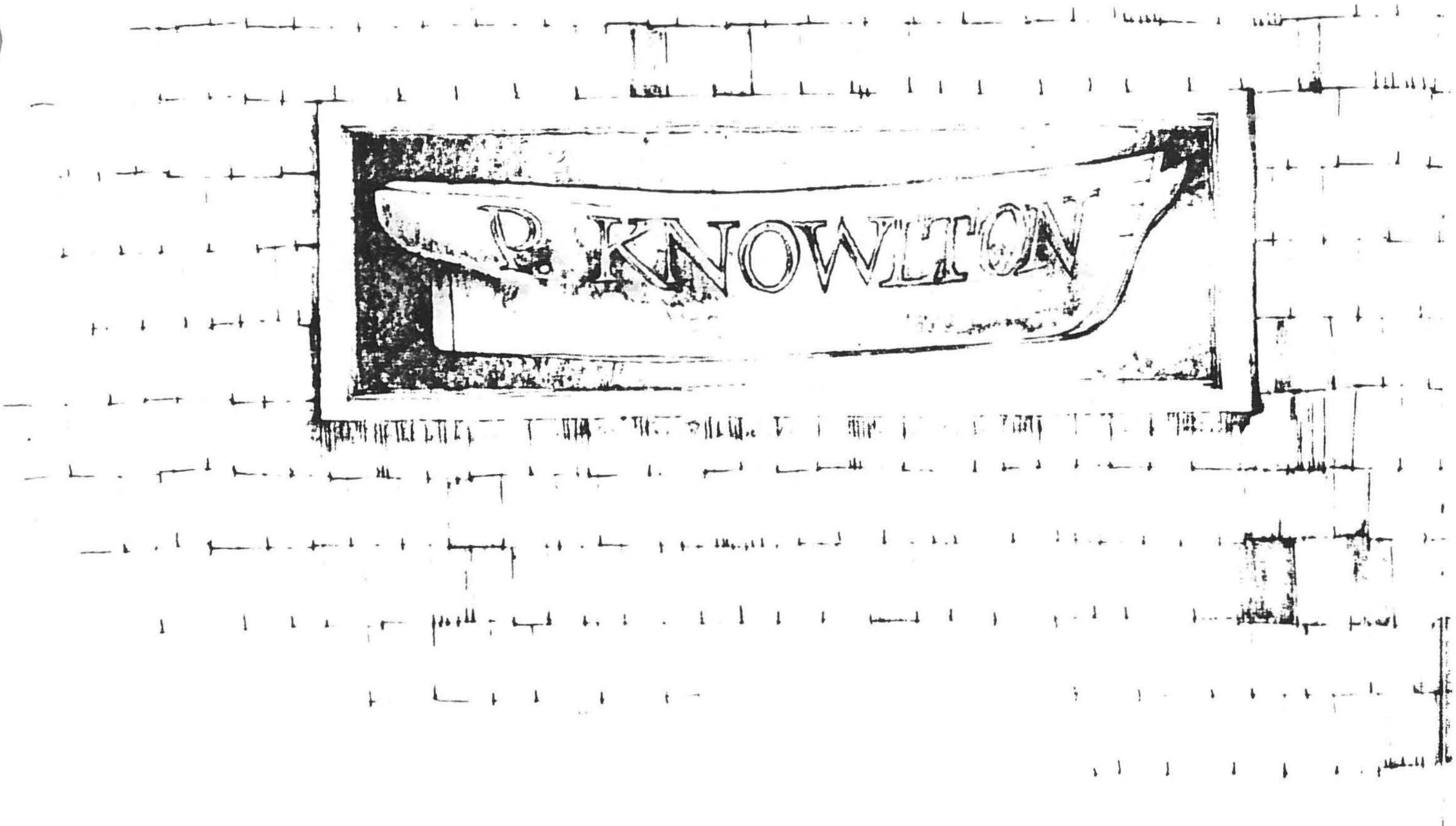
TWO BROTHERS of New Bedford, Massachusetts, John and Albert Ingalls, are wealthy men from the selling of whale oil and whalebone. Their whale oil lights lamps all over the United States, and their whalebone shapes the corseted figures of stylish ladies in ballrooms everywhere. They manage the counting house of Ingalls & Ingalls on Johnnycake Hill, and from their windows they can look down on the thick tangle of rigging that webs the edge of the harbor. Among the freighters, colliers, revenue cutters, and coasting schooners they can see three of their six whalers: *Edward B. Stetson, The Honorable Albert Bigelow,* and the *Double Eagle*. They know that their brig *Sally* is in the dockyard at San Francisco shipping a new mast. Good word from the whaleship *Simplicity* has just been received from a returning vessel. She is nearly full of oil and bone, almost ready to return from the Indian Ocean. The brig *Thea* has not been reported for seven months, but they do not worry, for in a voyage that may well last five years these lapses of communication are not uncommon. Further, the brothers Ingalls belong to the Religious Society of Friends, the Quakers. They are



gentle men for whom the will of God is a sure and purposeful force, controlling alike their destiny and the destiny of the *Thea.* A bountiful God, as real and immediate to them as the oaken floor they walk on, has provided the stuff of which to make floors and whaleships, an ocean full of whales, and a market for their oil and bone. To these gentlemen, wealth is not a badge of distinction but a burden of responsibility and an opportunity to glorify His name. Increasing that wealth is a duty and a covenant.

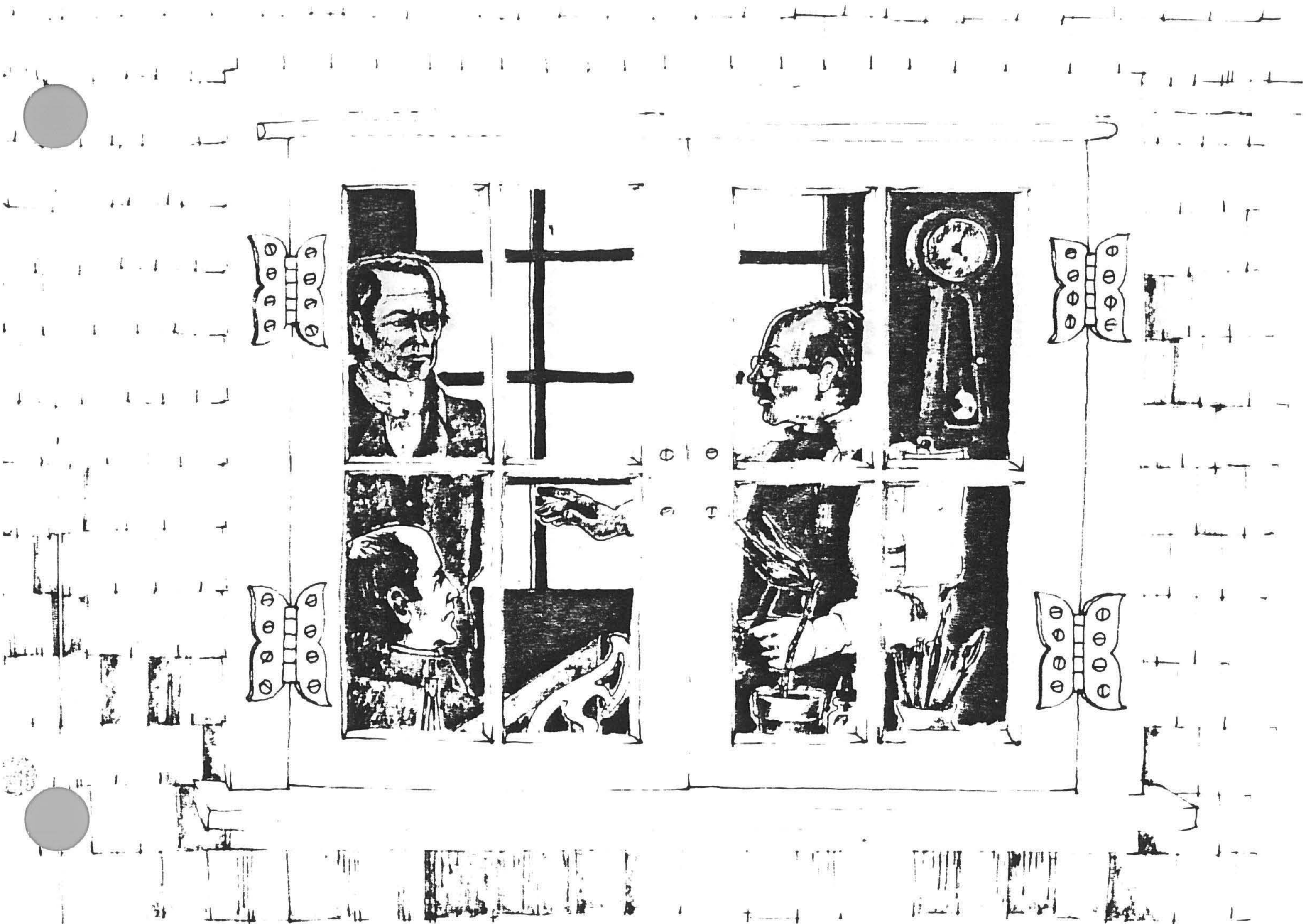
Today they are discussing the advantages of adding another vessel to their fleet. Pros and cons discussed, cash investment weighed against sure returns, the temper of the times accounted for, they decide: yes, a full-rigged whaleship to be built in Fairhaven, across the river from where they stand.

John consults his watch (oiled, as all fine watches are, with sperm oil) and notes that they yet have time to bespeak Mr. Percival Knowlton, master shipbuilder. As they stride into the street they talk excitedly. They are men of God and men of business, and they are happy men.



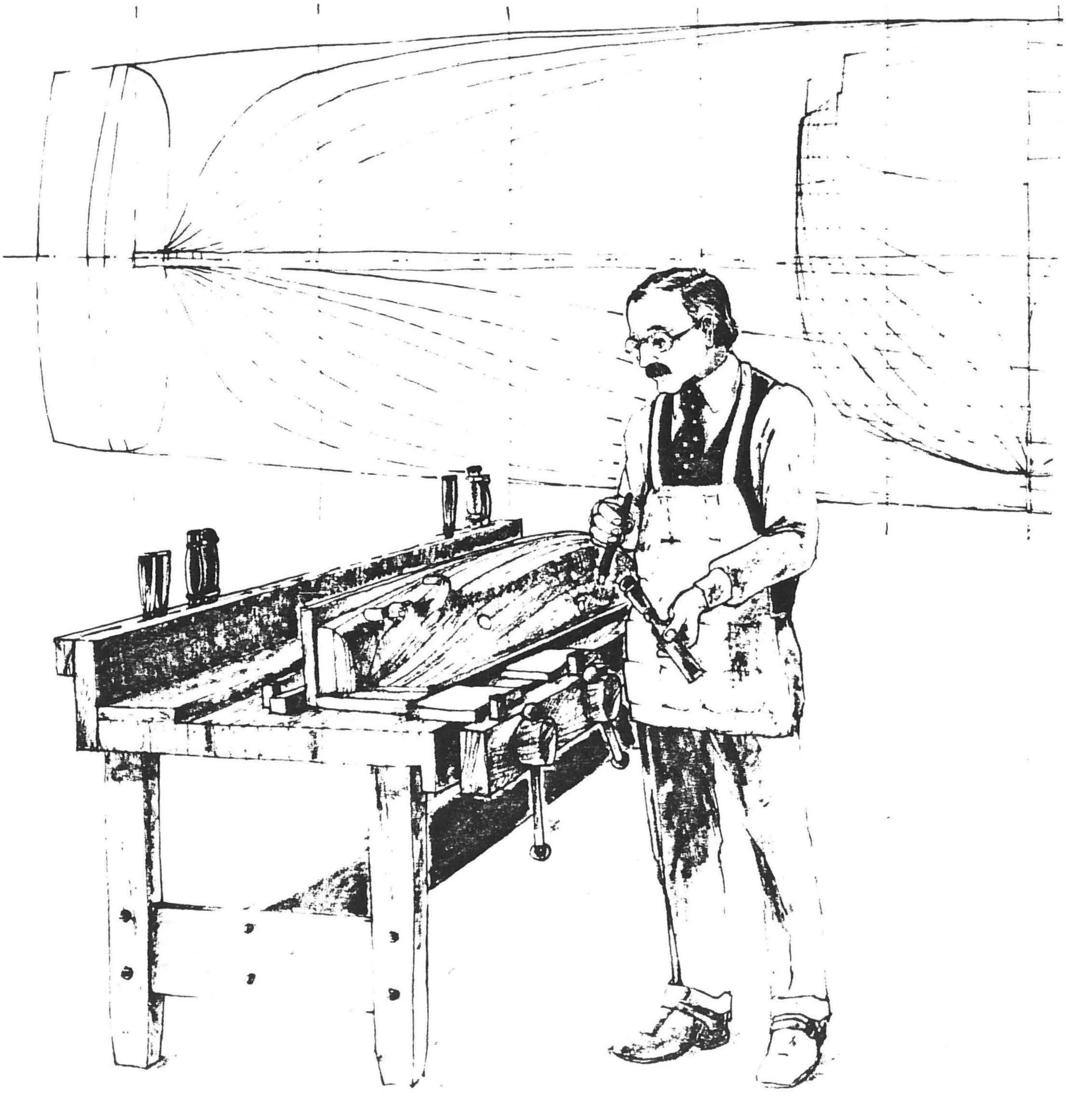
How does a ship take its look and form? Not all at once, not like a painting takes its look or a sculpture takes its form. A ship is too big, too complex. Every line in its forest of rigging is a strength or a weakness, every curve or smooth in its hull has something to say about the ship's way with the sea. Knowing how to build a ship is a skill that began six thousand years ago, a skill passed from one man to another, each man making his contribution or adding the example of his mistakes. Shipbuilding began with little, delicate coastal boats and grew to the complicated skill of building great warships, merchantmen, and world-circling passage makers.

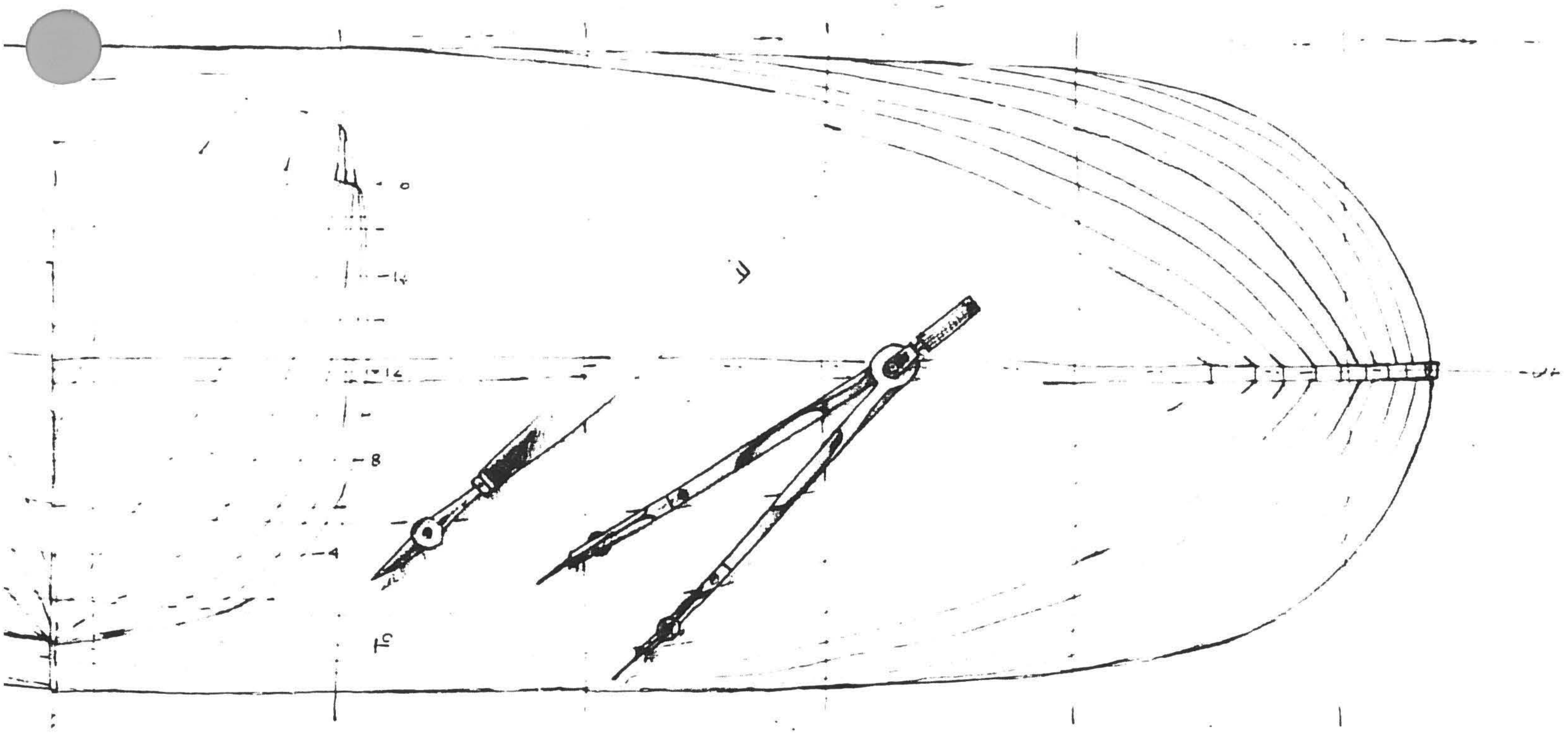
Designing a ship is a great responsibility. The lives of the men who sail her out to the storms depend on the designer. The fortunes of the men who have her built depend on the designer too—the fortunes of the brothers Ingalls as they visit Mr. Knowlton of Fairhaven. Mr. Knowlton is not a member of the Society of Friends, nor of any church anyone knows of. He smokes long black cigars brought from Honduras on the packet boat, he swears and drinks and worse, but the brothers trust him. He has steady, unwavering eyes, and if his speech *is* peppery, it is calm and honest.



They sit before Mr. Knowlton's stove and describe their needs: a whaling ship of about 300 tons, about 100 feet along the deck, with a good beam of 27 feet (her width) and about 16 feet for draft (how deep she will lie in the water). Yes, Mr. Knowlton agrees that a good beam is a comfortable quality in a whaleship. Yes, he can present plans and estimates in a month and if all is well the building can begin in the spring, yes.

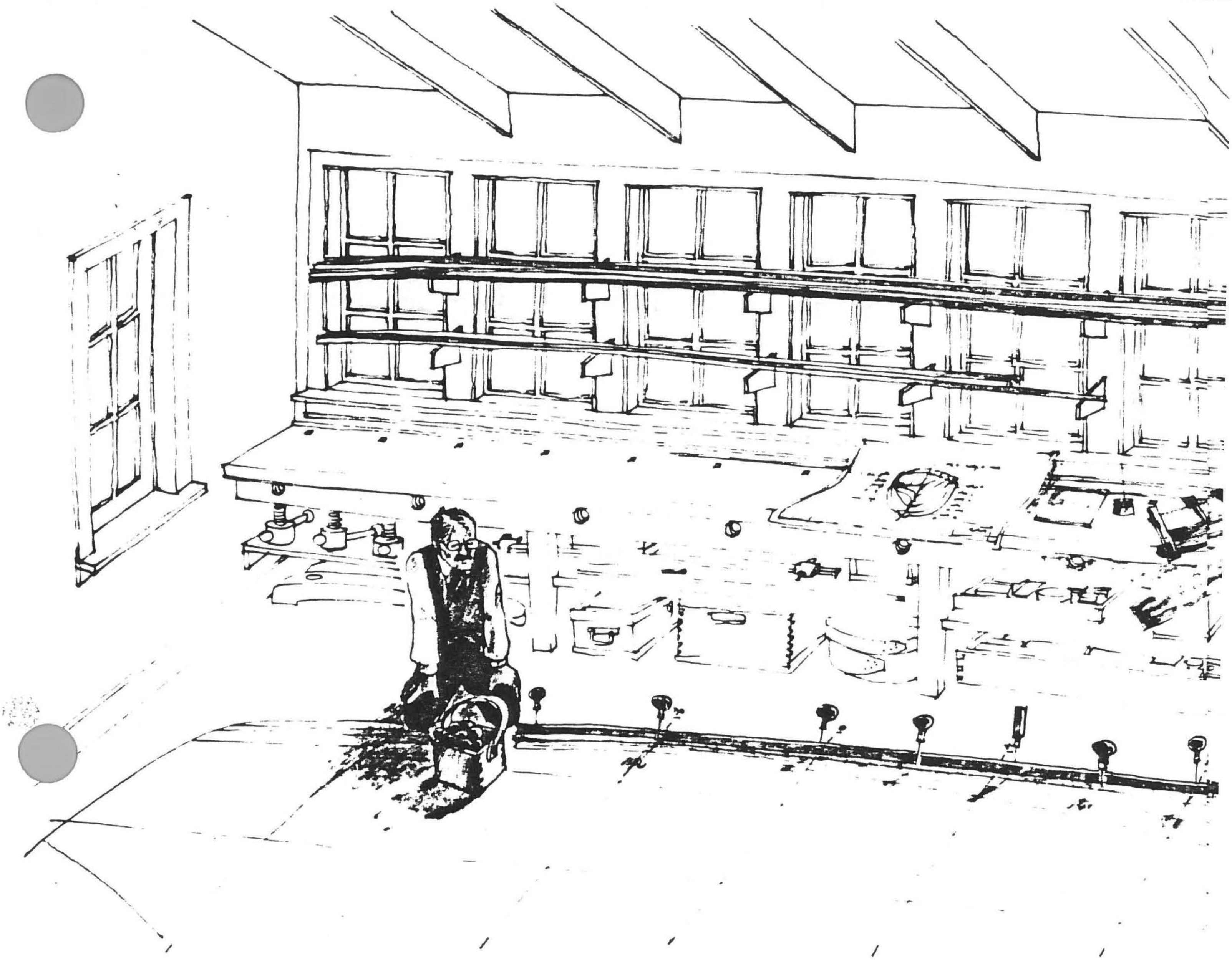
The brothers Ingalls take their leave; it has been an exciting day for them. Mr. Knowlton's head begins to bubble with the needs of his new project . . . the design of the hull, the lumber, the hardware, the workmen, the time of year. His responsibility begins.





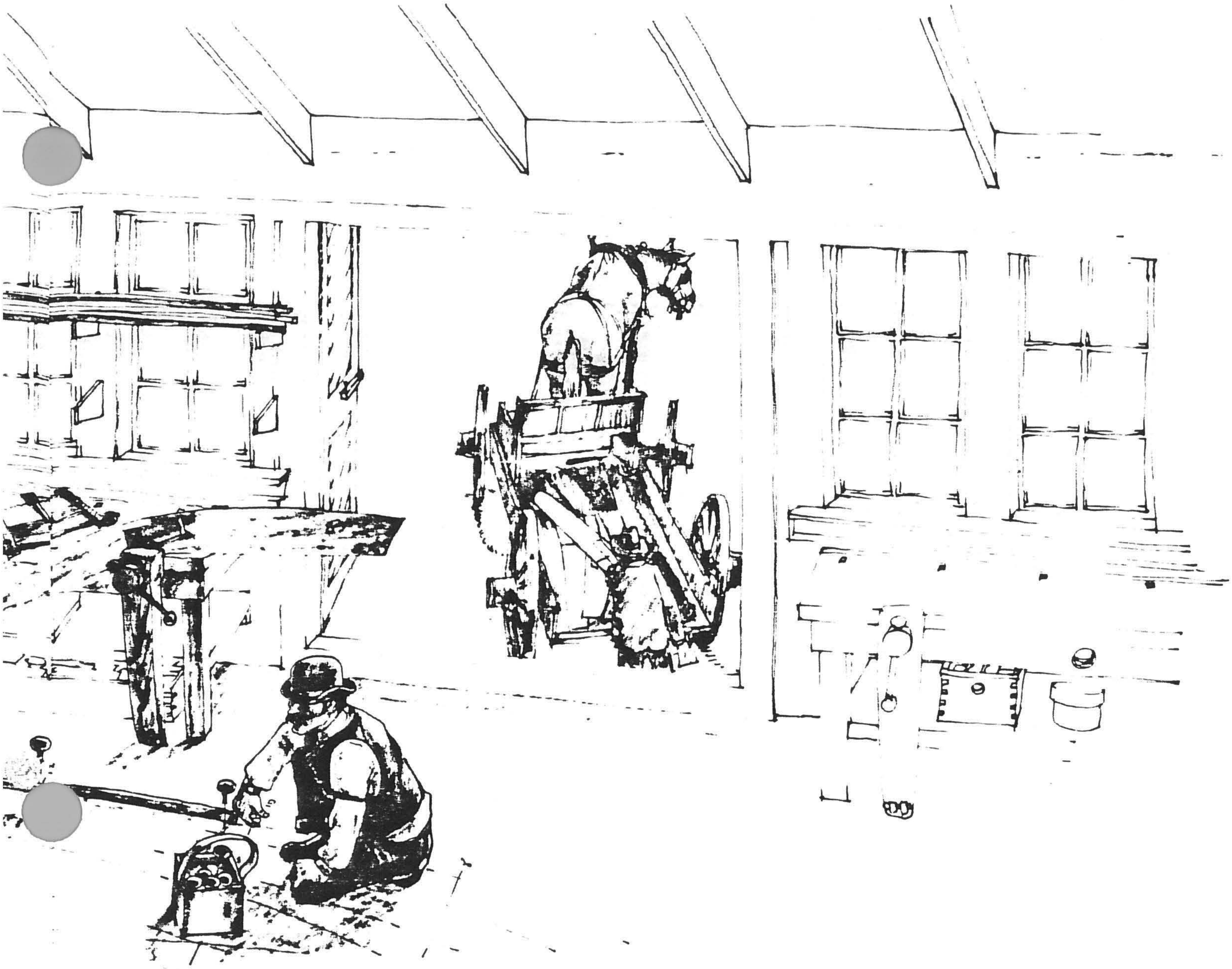
The ship begins. The first way anyone will see the ship is as a small model, or really a *half-model*. Mr. Knowlton lays up layers of wood held in place with wooden pins and he carves away at this wooden layer cake to find the shape of the hull in it. It is a way to see the real shape of the hull, to see the water cut by the bow and eased aside, to picture the water flowing around it, to see the bulk of the cargo hold under the water, the flow rushing back to meet the rudder, the *wake* (the waves shouldered up by the ship's movement) smoothing away under the stern.

The half-model is also a tool, a way of making precise drawings of the ship. When Mr. Knowlton is satisfied with the shape (he will work on it for a week and look at it for weeks afterward), he will unstack the layers of wood and trace around them. When all the lines are set down together he—and his workmen, and the apprentices learning from him, and even the brothers Ingalls—may see the gentle curves of the hull. Together, those curves are called the *lines* of a ship, and they are the plans for its building.



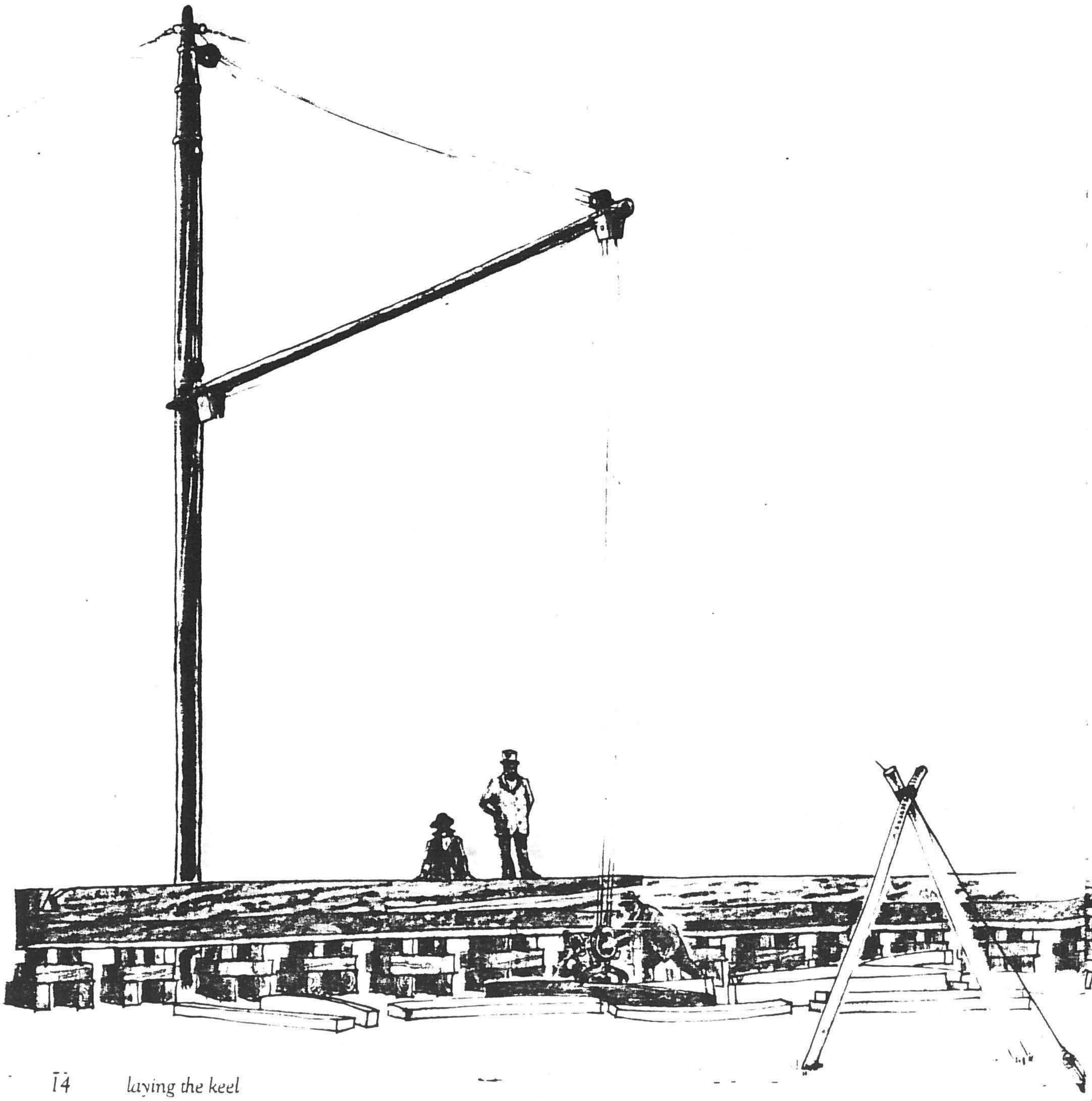
Now the plans are to be *lofted*; the small-scale drawings of the lines will be enlarged to full size and laid out on the smooth floor of a wide room, the loft (attic) of a large shed or warehouse. Most masterbuilders were finicky and secretive about the way they lofted their plans; they taught their methods only to their apprentices and the workmen who helped them, the *boss-liners*, and they jealously guarded these methods and special tools and mathematics from everyone else.

When the lines are laid down, they cut wooden patterns for each of the ship's ribs and timbers. It is now toward the end of winter and the *hewers*, the men who will



cut and shape the trees to fit these patterns, are anxious to begin their work before the spring thaw sends sap up into the oaks and tamaracks, for sap-wet wood will twist and warp and set the ship out of true. This is not a boat to last one season.

Off they go at last, small teams of men in sleds and wagons drawn by thick-limbed draft horses, up into the woods of Acushnet and Mattapoisett, Tinkamtown and Rochester, to find the big trees with just the right curve for that number three rib, and a good clear piece for the apron. The ship is lying with the patterns carried in their sleighs, and it is standing quietly in the trees of the forest.



14 laying the keel

The keel is the ship's backbone, her center line, her focus of strength. It is early spring, the yardmen still wear gloves and mufflers, and the keel is being laid. It is almost a hundred feet long and as straight as a tight string, built up out of hewn oak logs 16 inches square, and shoed along the bottom with a 3-inch sole of tamarack. The logs are fastened along their length with scarf joints, diagonal cuts that even out the load. They are fastened through their 3-foot depth with iron bolts driven through undersized holes with sledgehammers and bent over on the top. The sole that will protect the keel from scraping is fastened with pegs, so that it may be replaced when it is worn.

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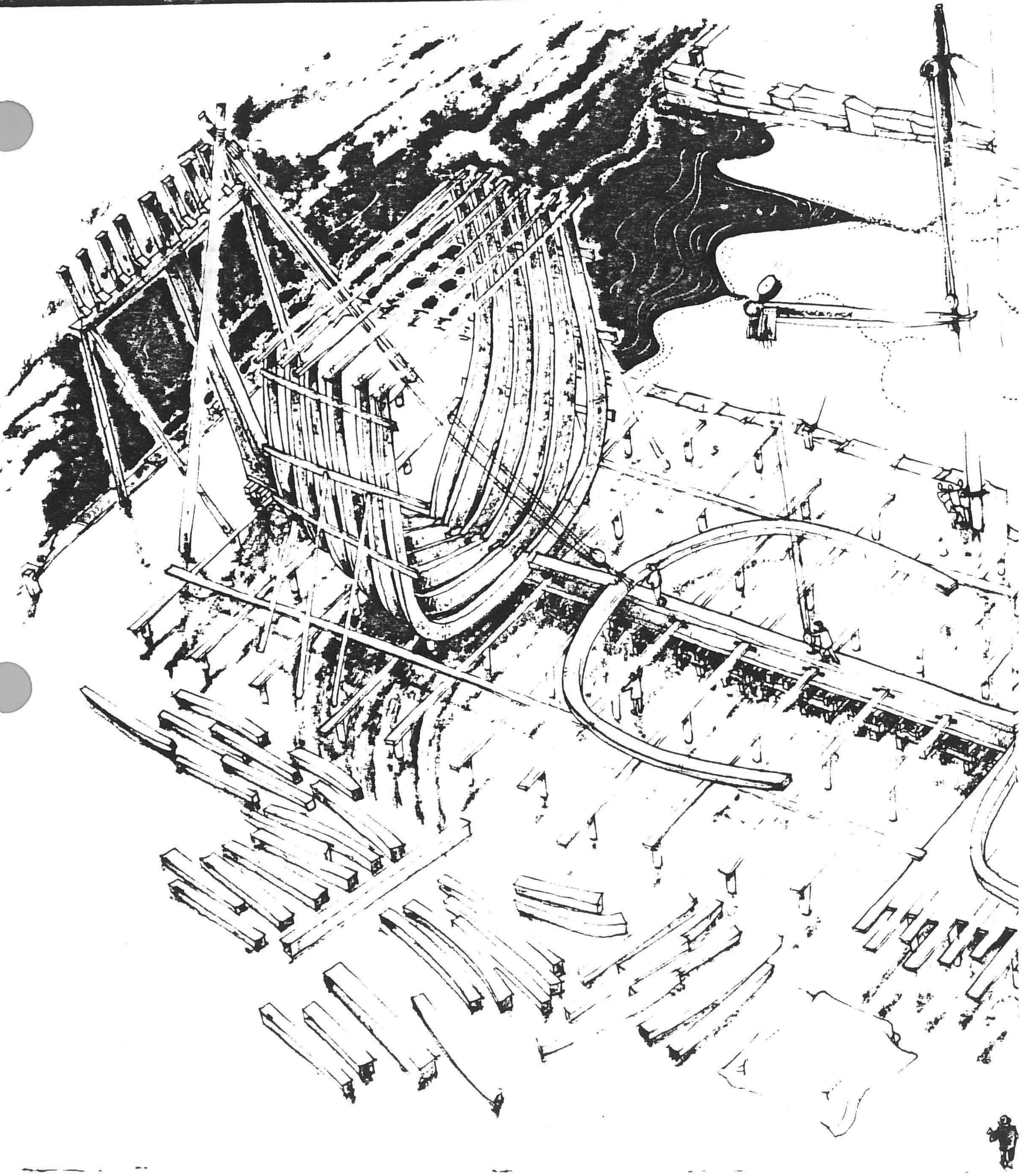
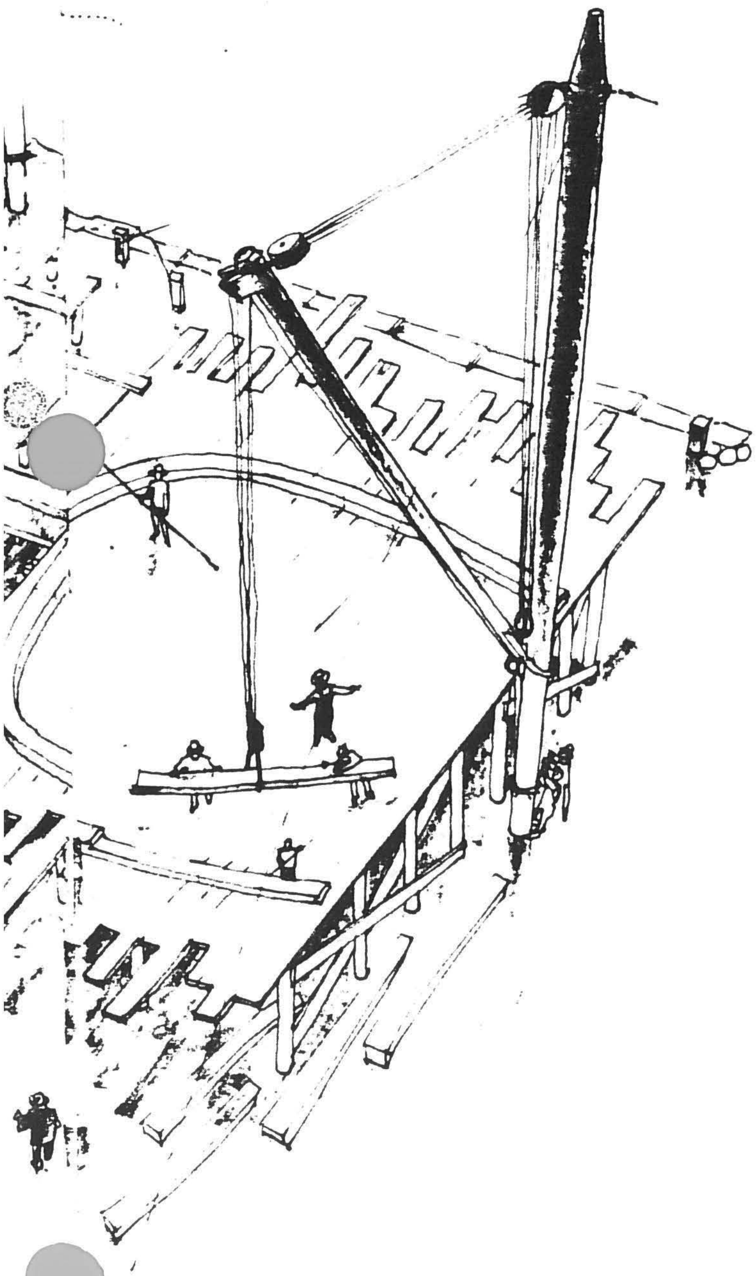


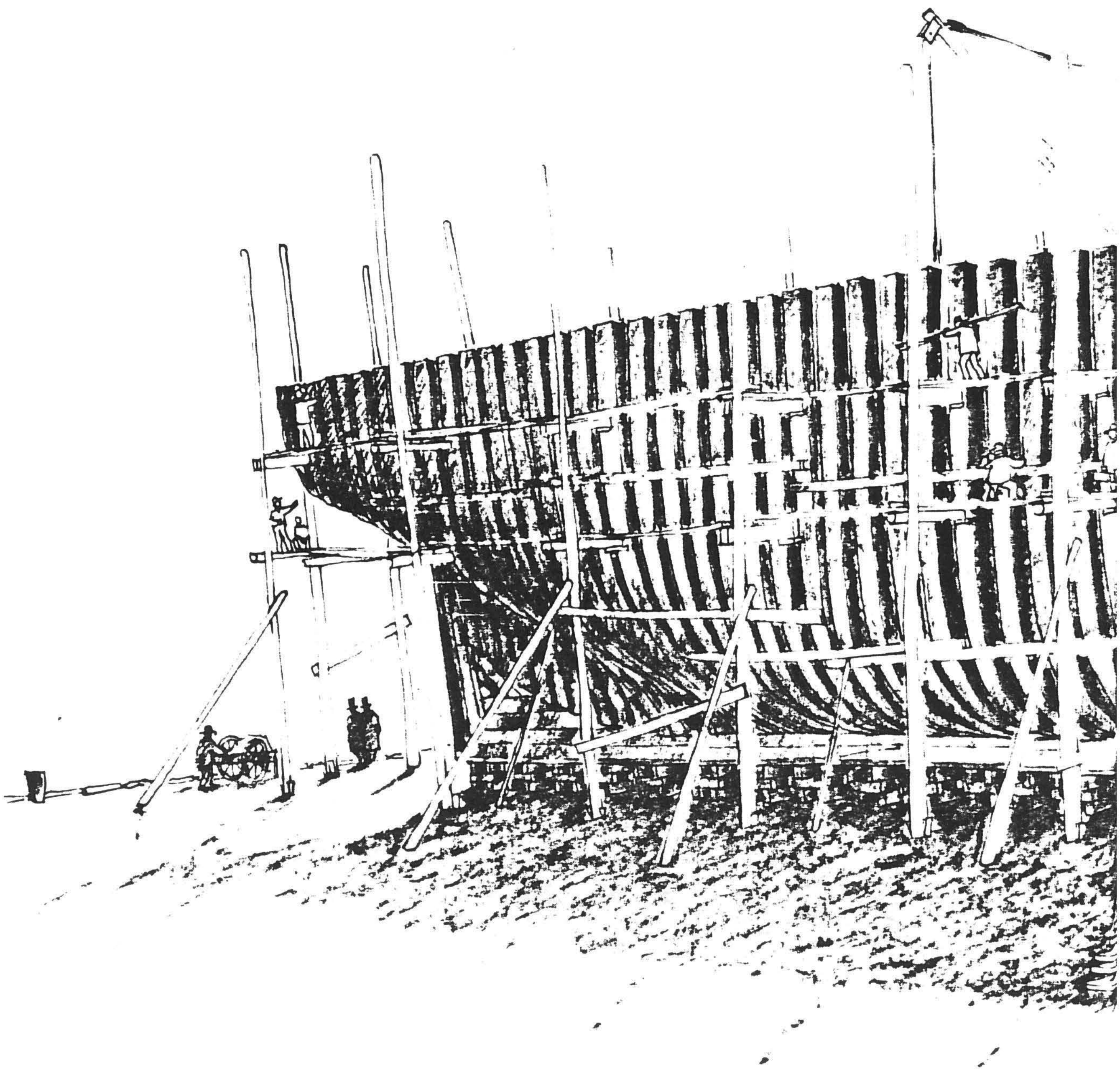
16 *the ribs*

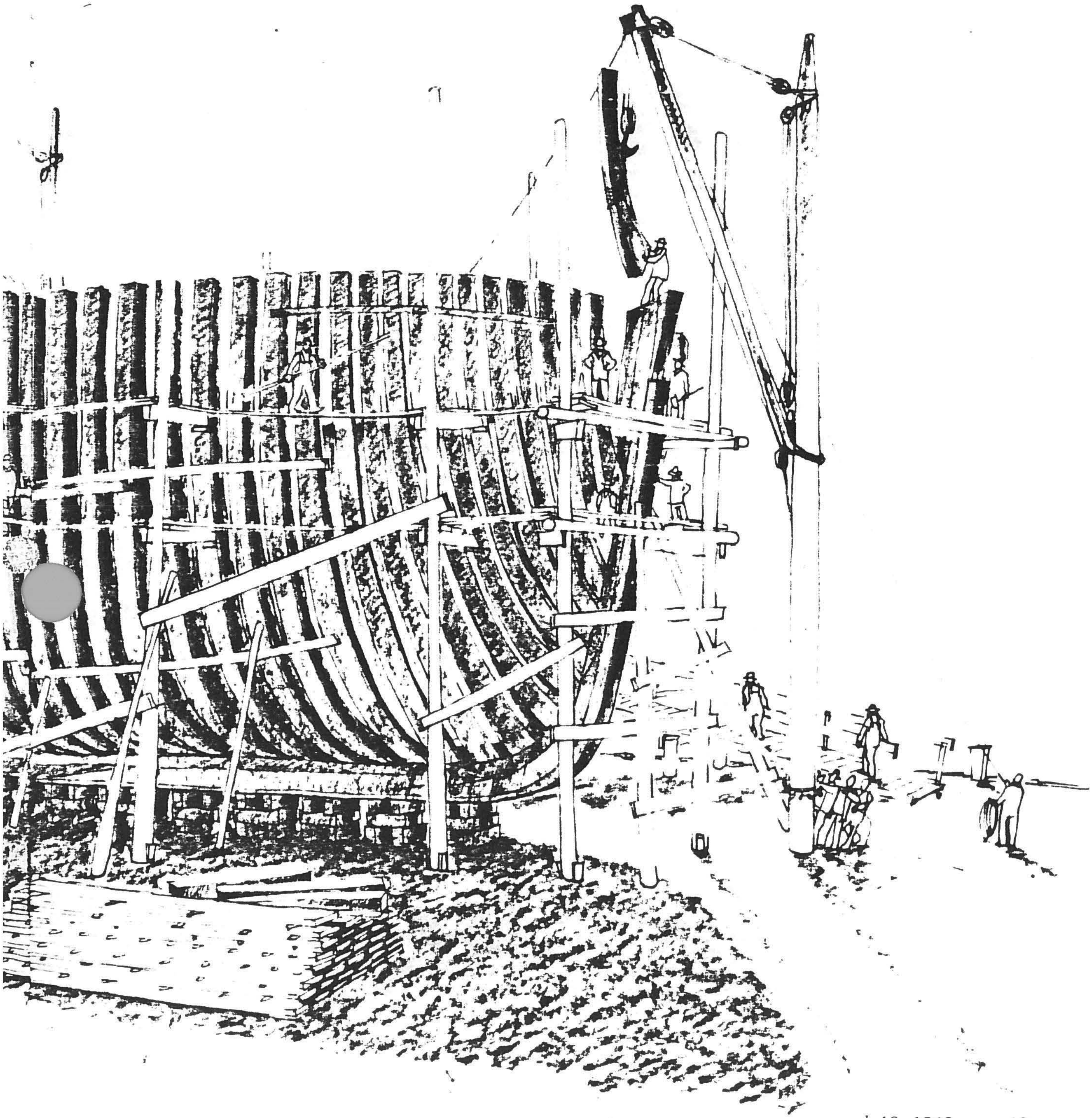


Like a great, clumsy Chinese puzzle the ship is fitted together. Forward, a platform is built on the keel and on it the *timbers* (ribs) are assembled. Each timber is *double-sawn:* since no onepiece of timber can make the whole rib, many pieces (called *futtocks*) are halved together so that the butt ends join beside a solid length. The pieces that span the keel are called *floors,* and they are notched so that the planking, the skin of the ship, will bed into the keel, into a notch called the *rabbet.*

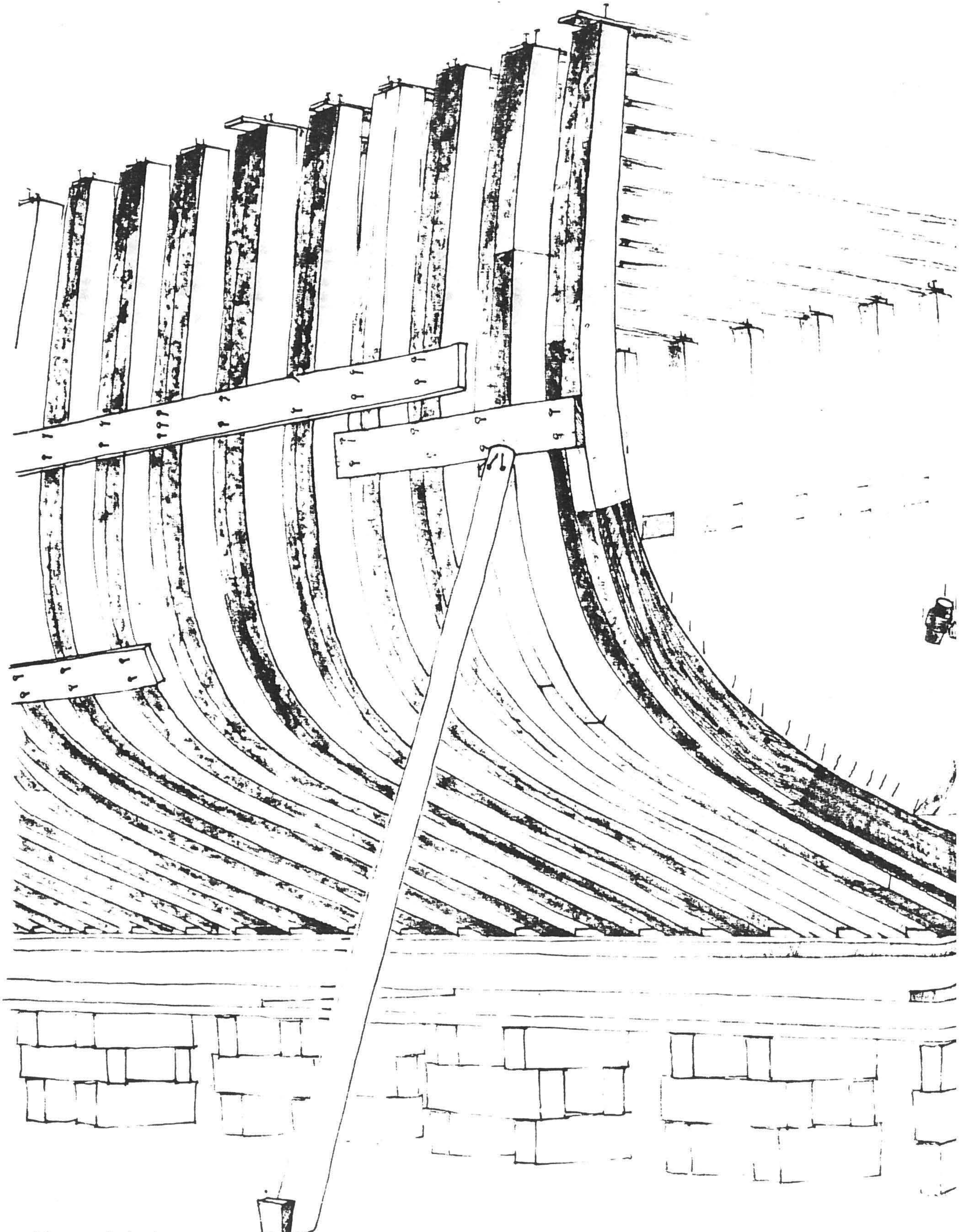
When a timber is complete and measured and trued, it is slid aft on runners and raised into place with gin poles and block and tackle and winter sweat. It is kept from sagging out of shape by *crossbands* spiked across its top, and held into the march of the other ribs with long planks called *ribbands.*

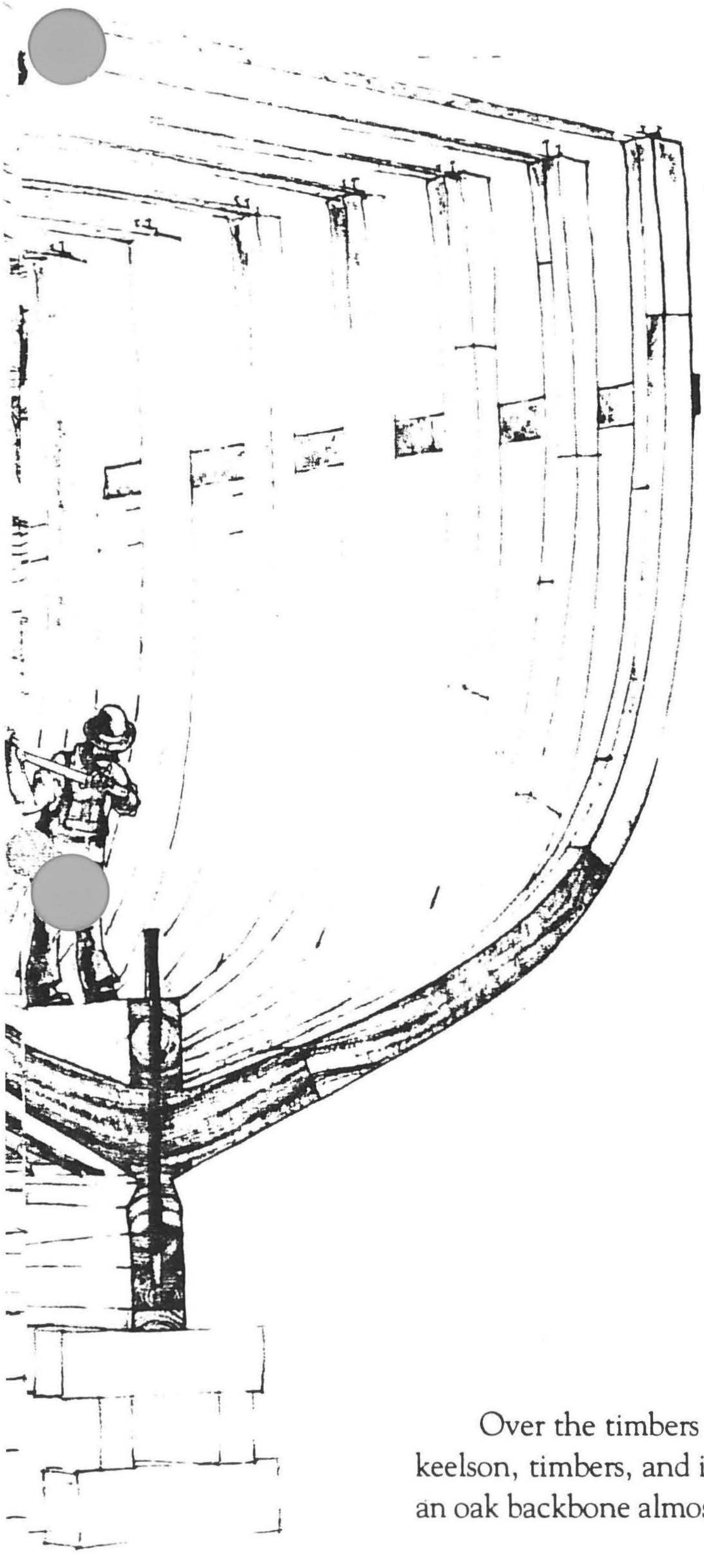
The shape of the hull is clear now. The last of the *cant frames* is being lifted into place. These are timbers that are not continuous across the keel but fit into the stem forward and into the deadwood aft. (The *deadwood* is the built-up fin that continues back to the rudder under the rising stern.)



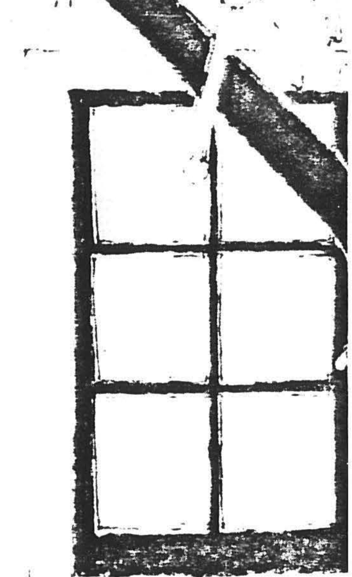


march 18, 1868

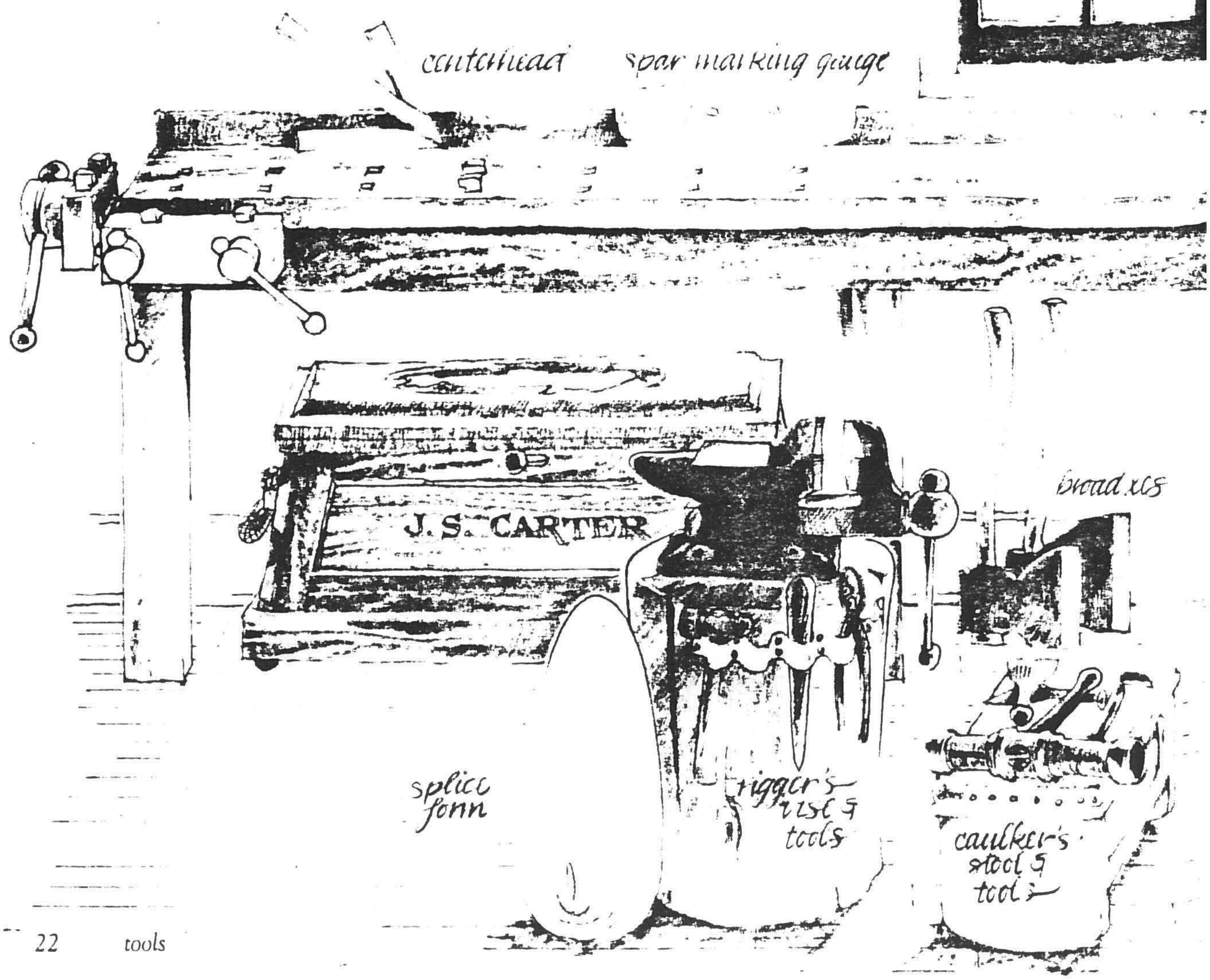




Over the timbers is fitted the *keelson*. Drift pins are driven through keelson, timbers, and into the keel, clamping them all together to make an oak backbone almost 6 feet deep.

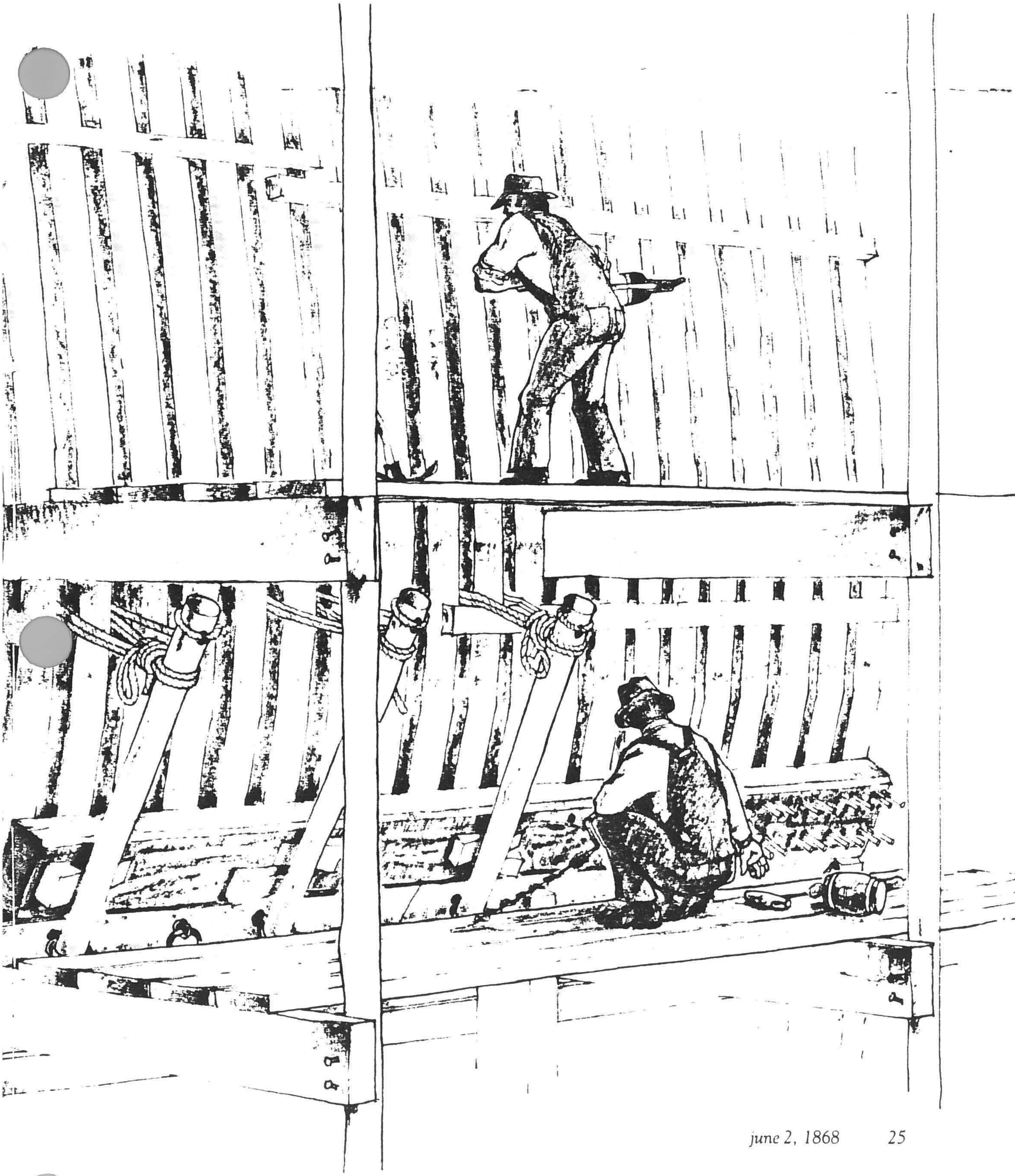


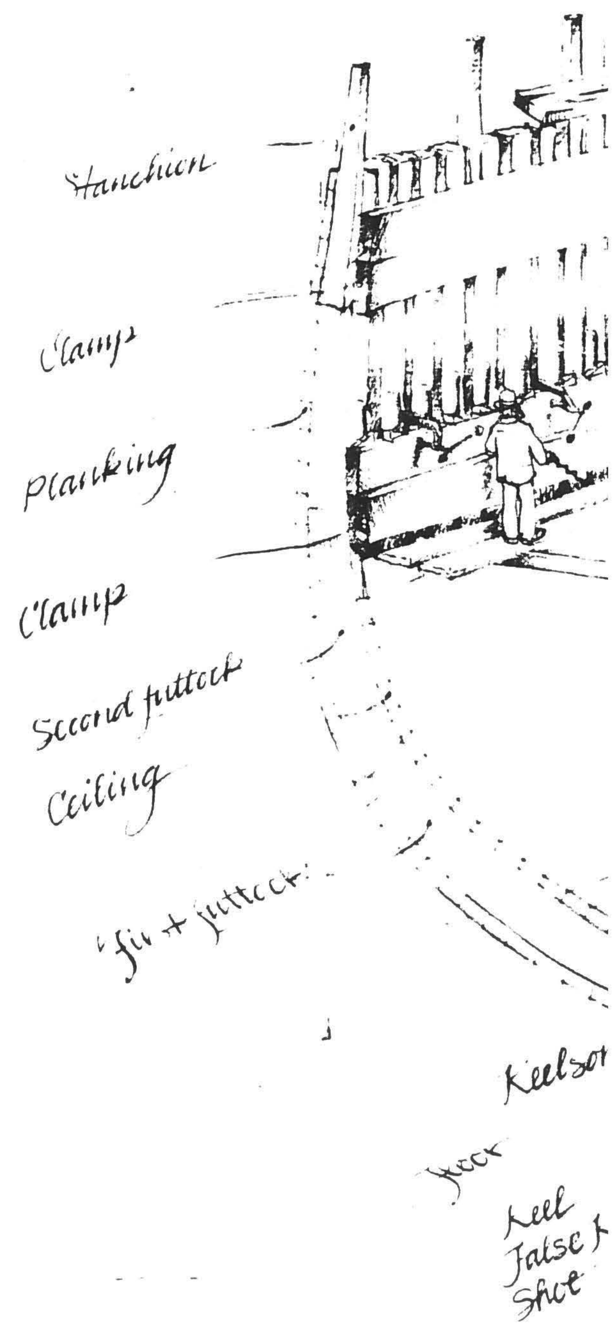
A late winter rain, and work on the hull is slowed. George Fearing is rolling oakum into strands for the job of caulking to come later. Oakum is loose hemp fiber bound with tar. He rolls it with his hand against a scrap of canvas thrown over his knee. It's a mindless, pleasant job near the warmth of the stove, among the tools.



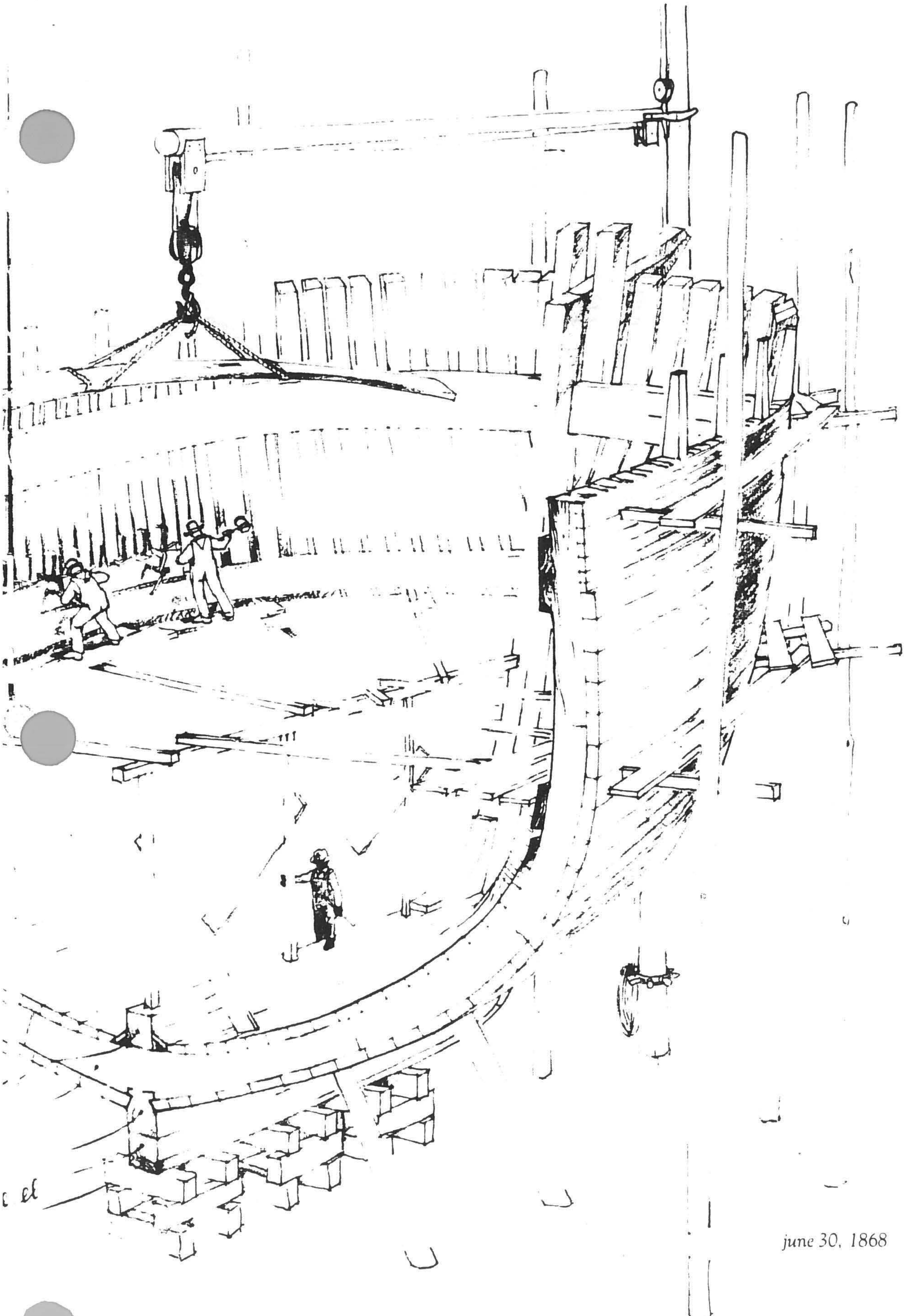

plumb bob
adz
adz
hammers
saw
spar planes
drawknife
spokeshave
sharpening stones
calipers
brace

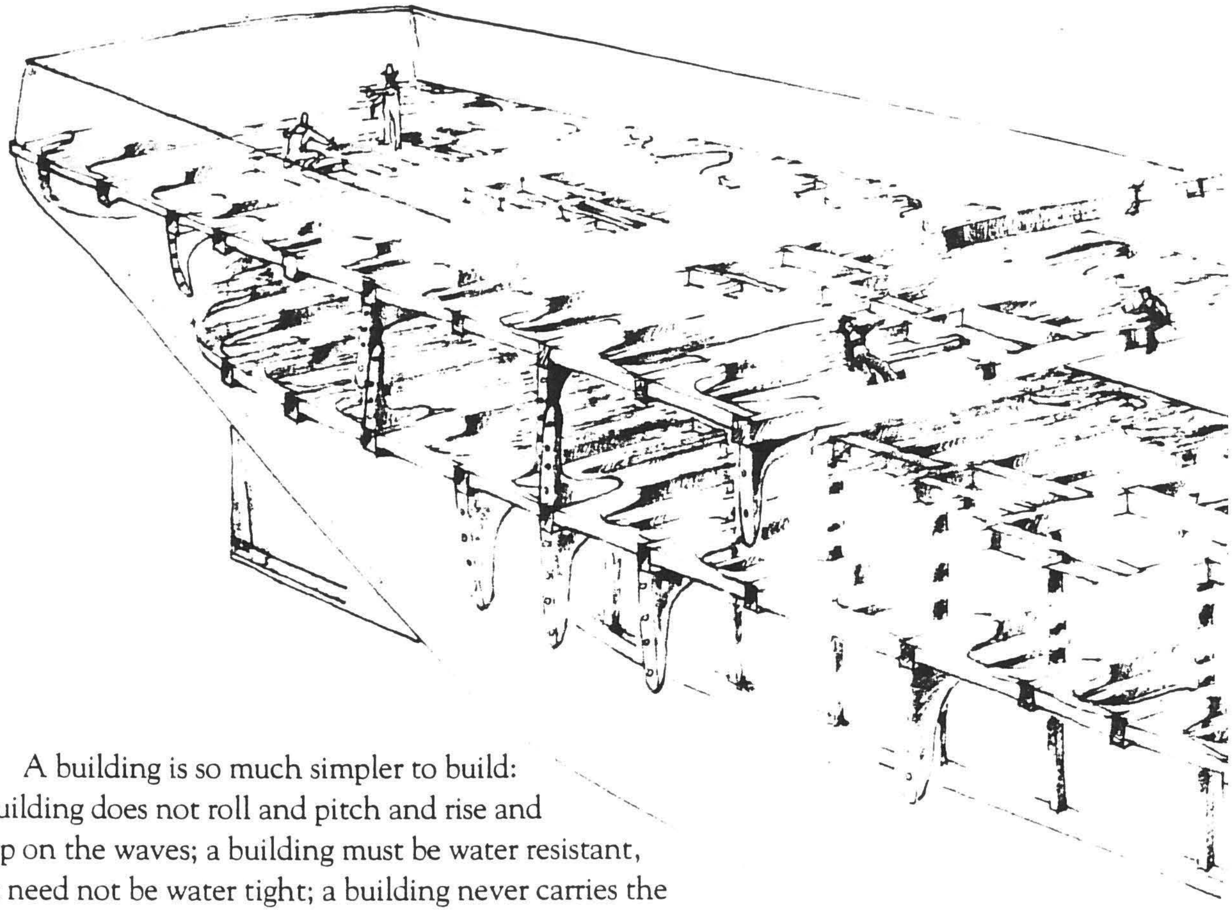
The skin of the ship is oak and white pine, hard and thick. Every plank is set to the ribs with care, its edges planed to meet its brothers square and flat, outside corners beveled to make it easy to wedge in the caulking. Under every *strake* (band of planking) the curving ribs are marked and trimmed with a lipped adz to make a flat, true-bearing surface. The men who mark and trim are called *dubbers*, and they are wonderfully delicate with their big, razor-edged adzes. Planks *amidship* (at the middle of the ship) lie easy with a simple curve to follow; they are *shored in* with posts and wedges and fastened with locust pins called *trunnels* (for "tree nails"). Each end shares half a rib, and a plank is trunnel-fastened four times at each rib. Forward and aft the curves are complex and more pronounced. For that work the big kettles start to boil, shooting steam into the long steaming boxes where stiff planks lie sweating out their stubbornness. As the box is cracked open a white plume of steam rushes up and Knowlton's men pluck a hot plank out with leather gloves and hooks. They rush it, still whippy with the heat and damp, up to the ribs and clamp it down to its curve before it stiffens again. The trunnels, almost twenty thousand of them, give the ship a rash of stubbly texture before the dubbers trim them flush.



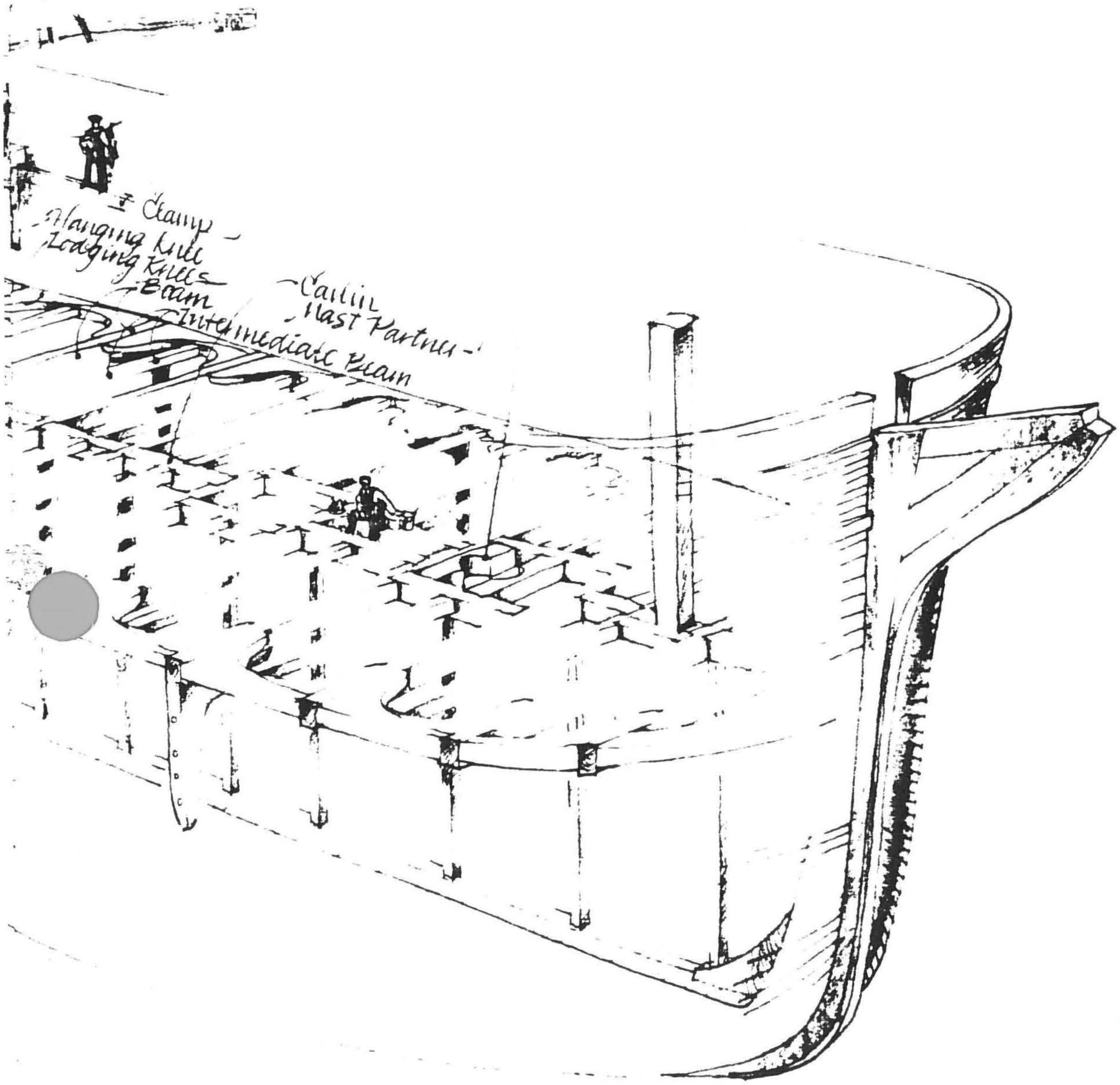


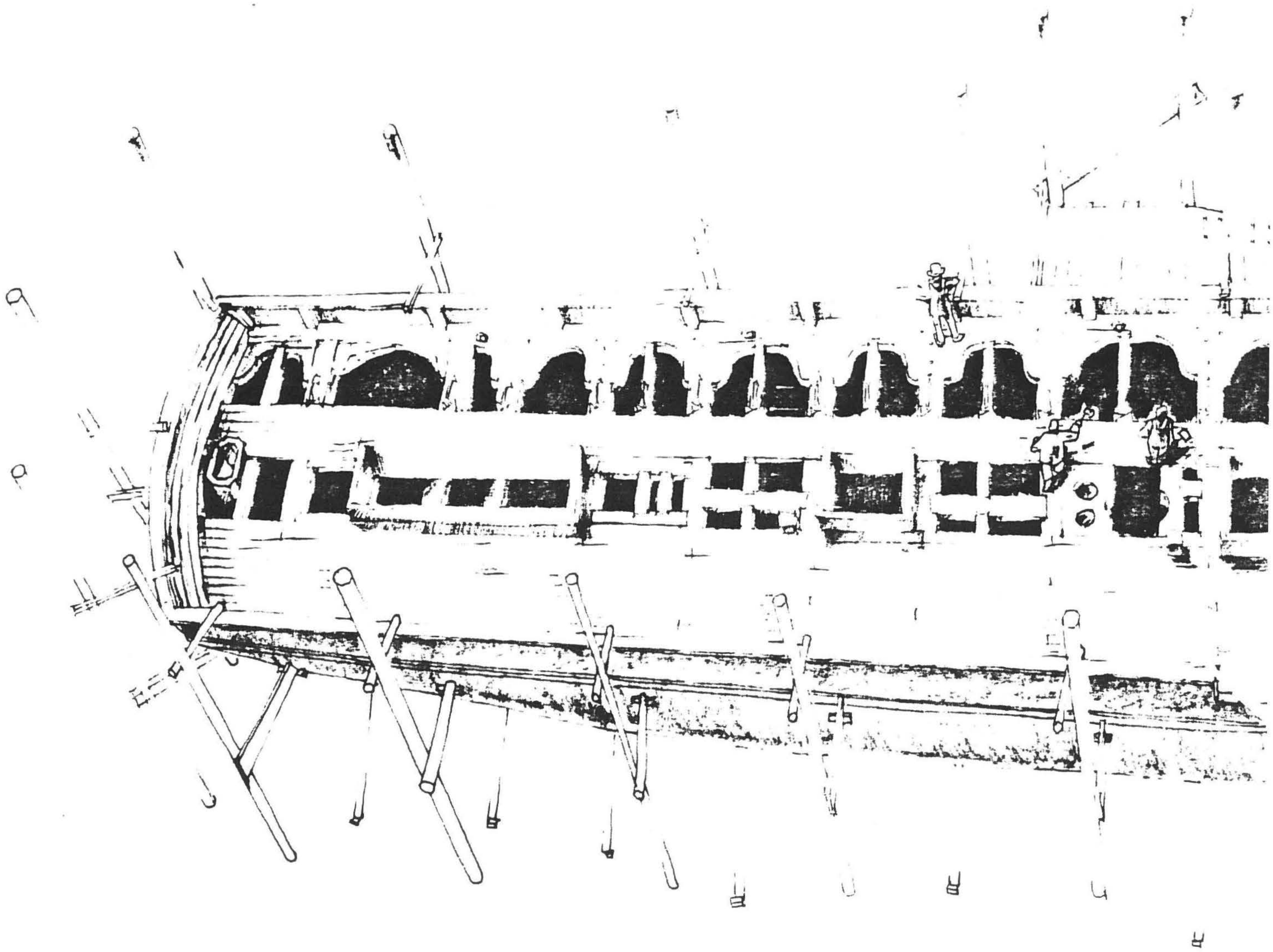
A wooden ship has an inner skin and an outer skin. Inside the ribs the men are laying in the *ceiling*, planks just as thick and strong as the outer shell. At two levels they are fastening *deck clamps*, heavy timber shoulders that will take the butts of the deck framing. The tops of the ribs are trimmed and uprights called *deck stanchions* are fastened between them (these will carry the lighter planking of the *bulwarks* that enclose the main deck).



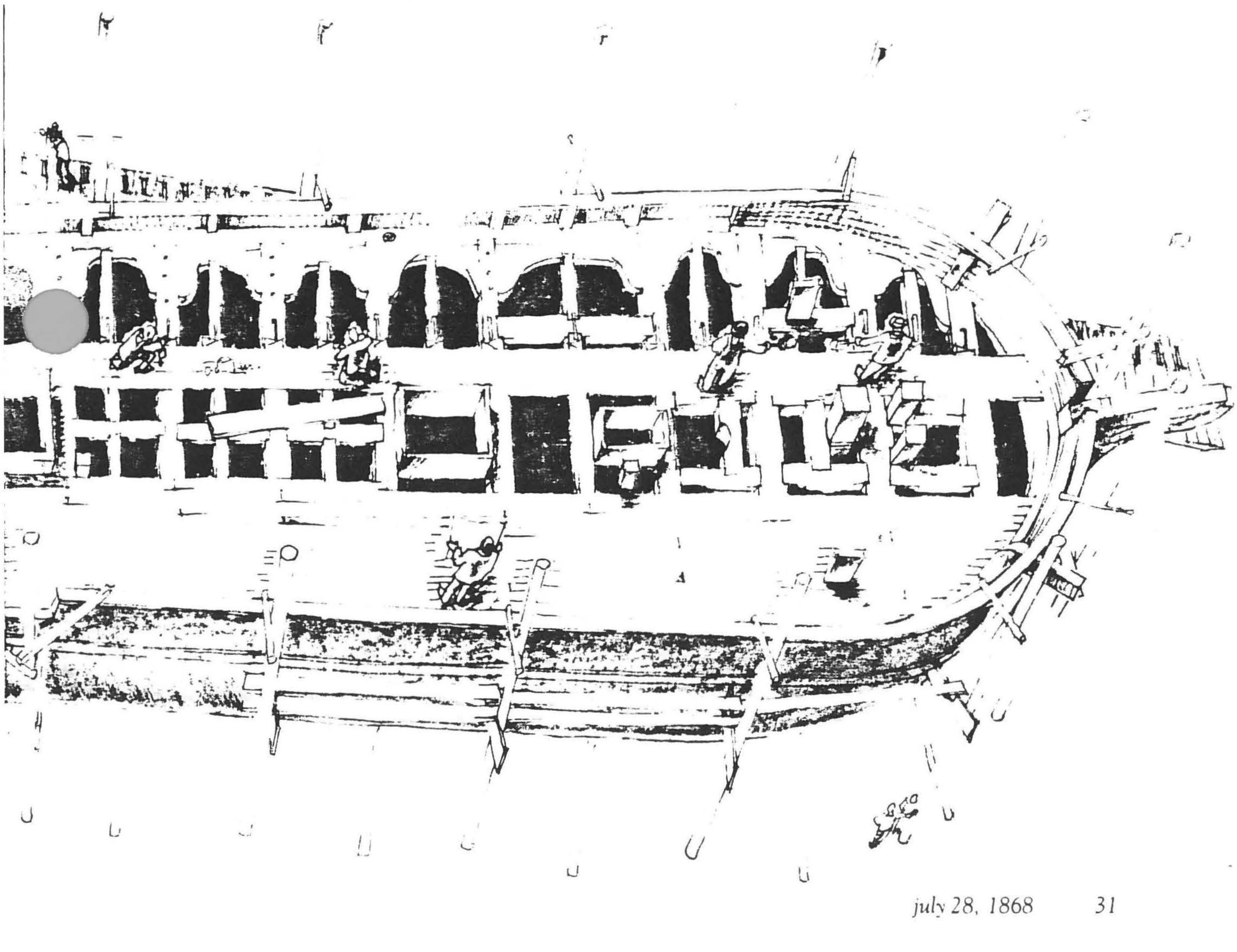


A building is so much simpler to build: a building does not roll and pitch and rise and drop on the waves; a building must be water resistant, but need not be water tight; a building never carries the shifting strain of spars and sails under the wind; a warehouse stores cargo like any ship, but it is not called on to move smoothly through the water. This ship must be so strongly built, so well braced and sturdy that it resists the strain, but it must also give a little, it must shift the tiny amount that makes the difference between creaking and cracking. You can see the deck stanchions reaching up from the keelson to support the lower *'tween-decks* beams at their midpoint. Running *fore and aft* (from bow to stern) between the main beams are *carlings,* and arching from clamps to carlings are the intermediate beams. Heavy timber is built into places that take heavy strain: mast partners around the openings for the masts, heavy construction to support the windlass and the posts that will take the pull of line and chain. Beams are braced by *knees* cut from the tough curving trunk roots of tamarack. The bow and stern are strengthened by wide knees called *breasthooks* and *quarter knees.*

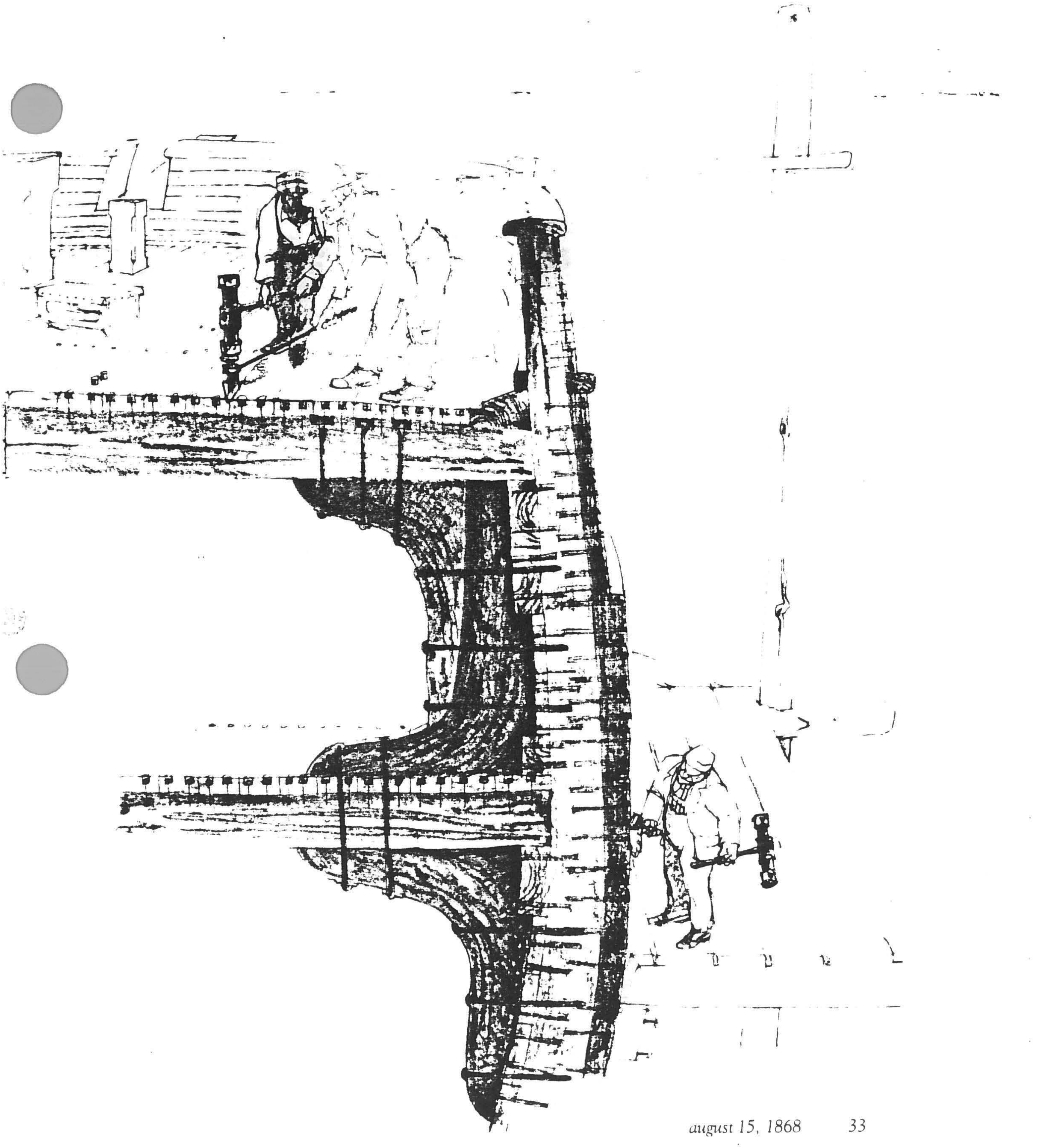

Clamp
Hanging Knee
Lodging Knees
Beam
Intermediate Beam
Carlin
Mast Partner

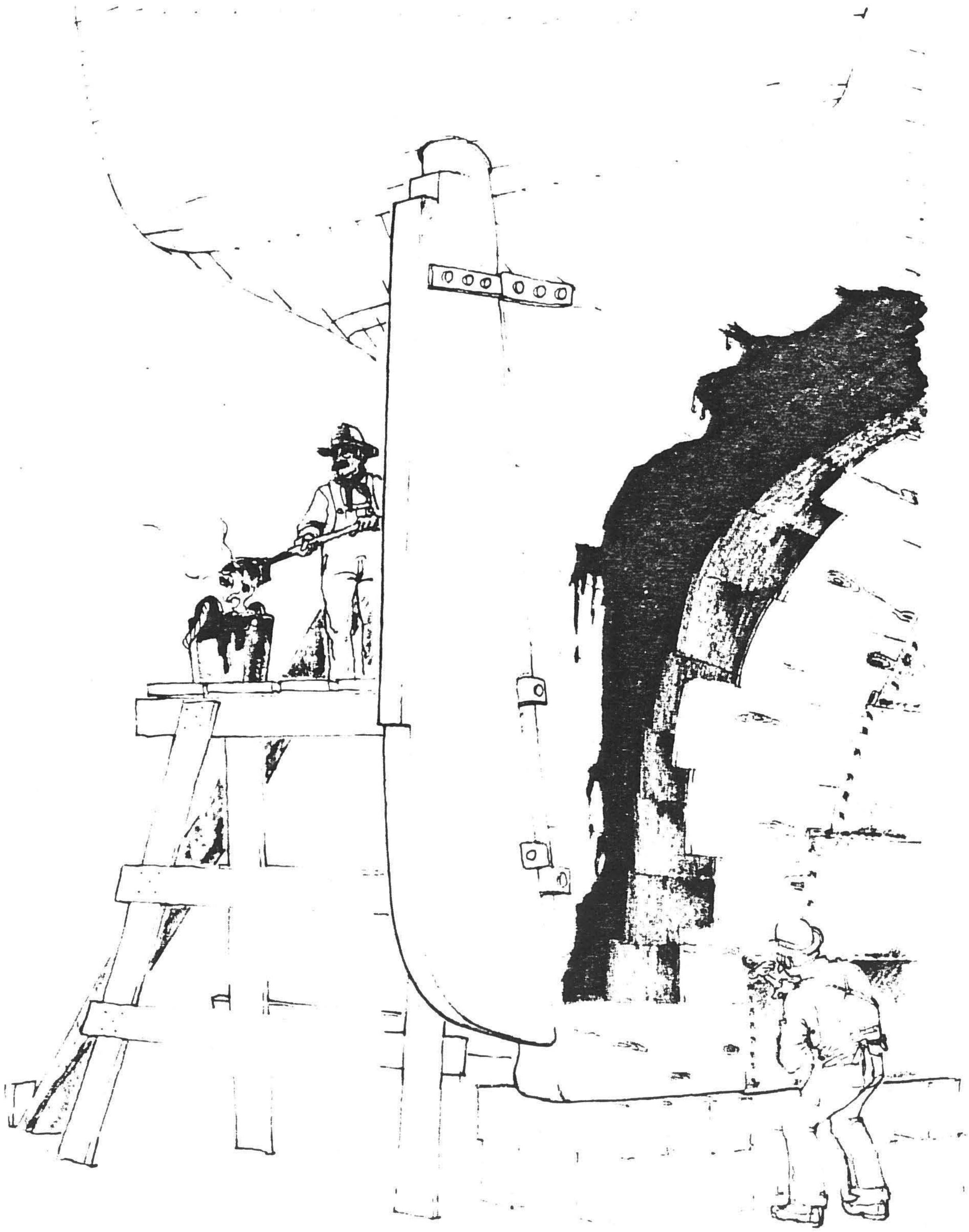


The *hatch coamings* have been fitted. They are boxes built around the deck openings to keep water out. Now the deck is planked around the coamings. Large staples called *dogs* are driven into the beams; with these as a stop, wedges are used to spring the pine planking tightly into place before it is spiked to the beams.



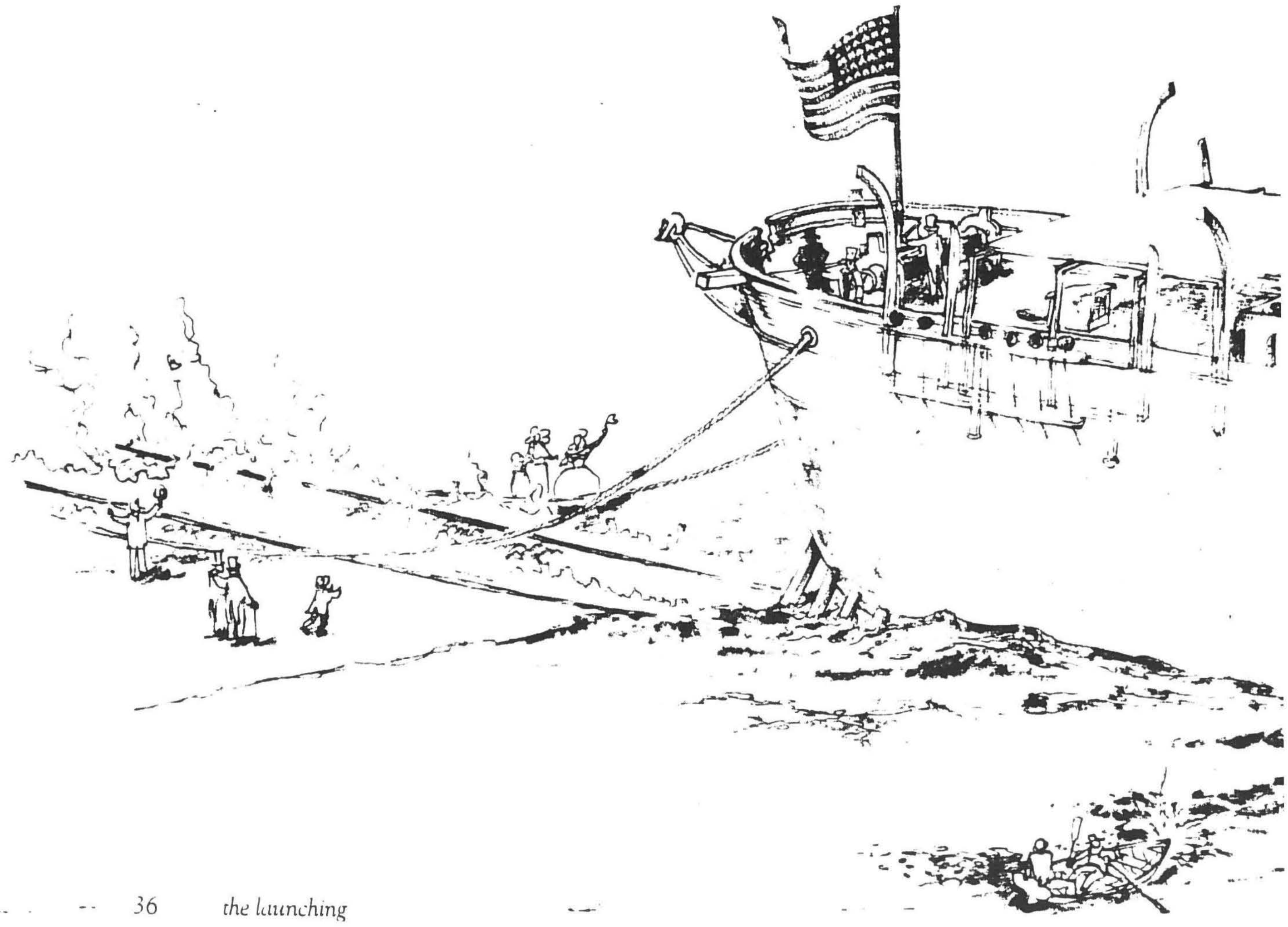
There is one sound peculiar to the shipyard, heard nowhere else. It is music to the shipbuilder and fills the brothers Ingalls with pride. It is the ring of the caulker's mallet. Every space between the planks must be filled to prevent leaking. The caulkers force in twisted hemp (from old tarred rope) called *oakum*. They use a broad-bladed *caulking iron* struck with a *caulking mallet* of mesquite wood or live oak, banded on the ends with polished steel. The hull seams are filled with three strands of cotton and oakum, then painted over with red lead paint. The main deck seams are given two strands and filled with hot tar. Almost seven miles of oakum will be driven into the ship, tap by tap. Swinging the gleaming mallets with tarry hands and huge forearms, the caulkers are a special brotherhood.





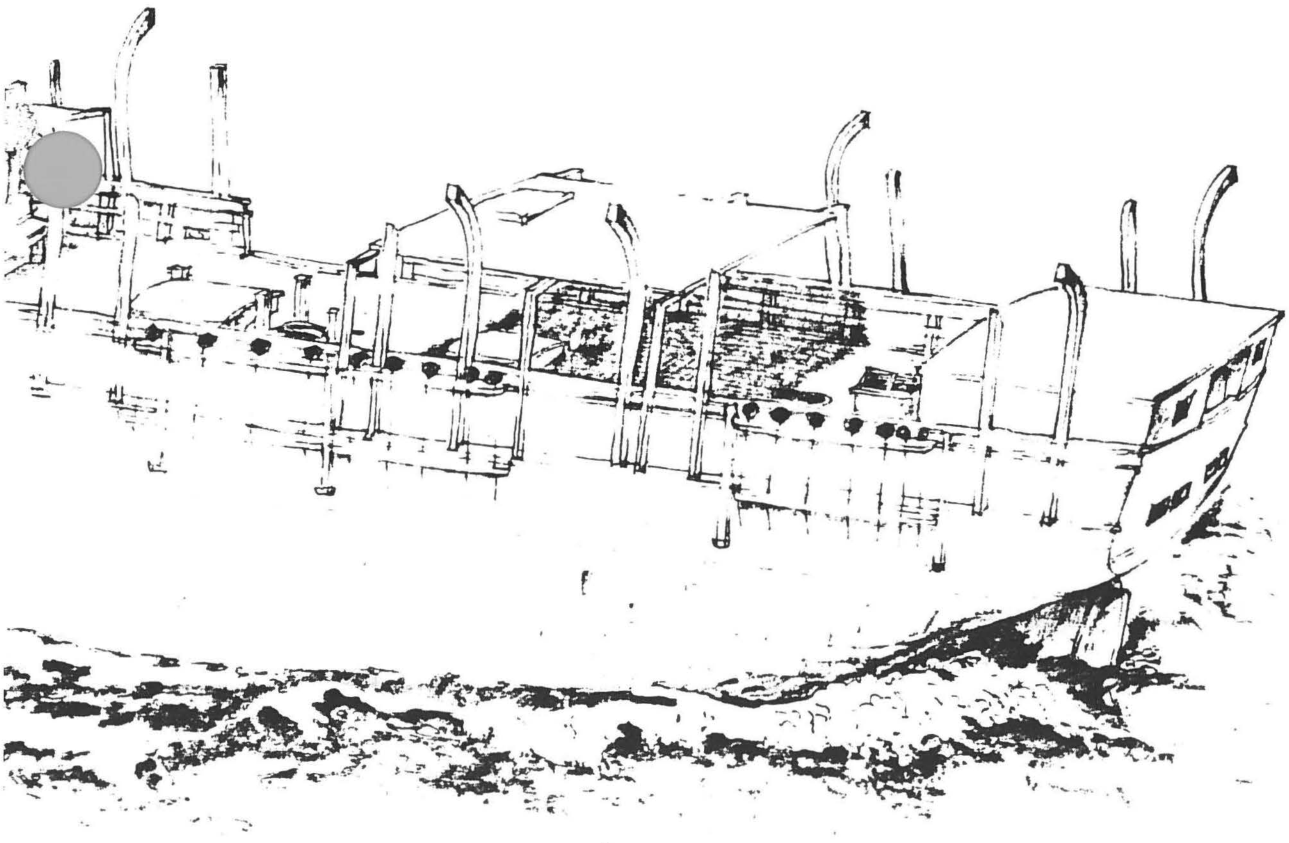
There is a record of an enraged sperm whale attacking a whaleship, ramming it, and sinking it, but one of the ship's main predators is much smaller: the worm. Wood-boring worms eat away at ships surprisingly quickly, and a few months in warm waters would weaken the ship beyond repair if it were not protected by a sheathing of copper from the keel to the water line.

The oaken planking is covered with pitch, then a layer of felt, over which carpenters fit a sheathing of thin white pine. Finally the hull below the water line is encased in metal—copper or an alloy—which will turn away worms and discourage other marine growth.



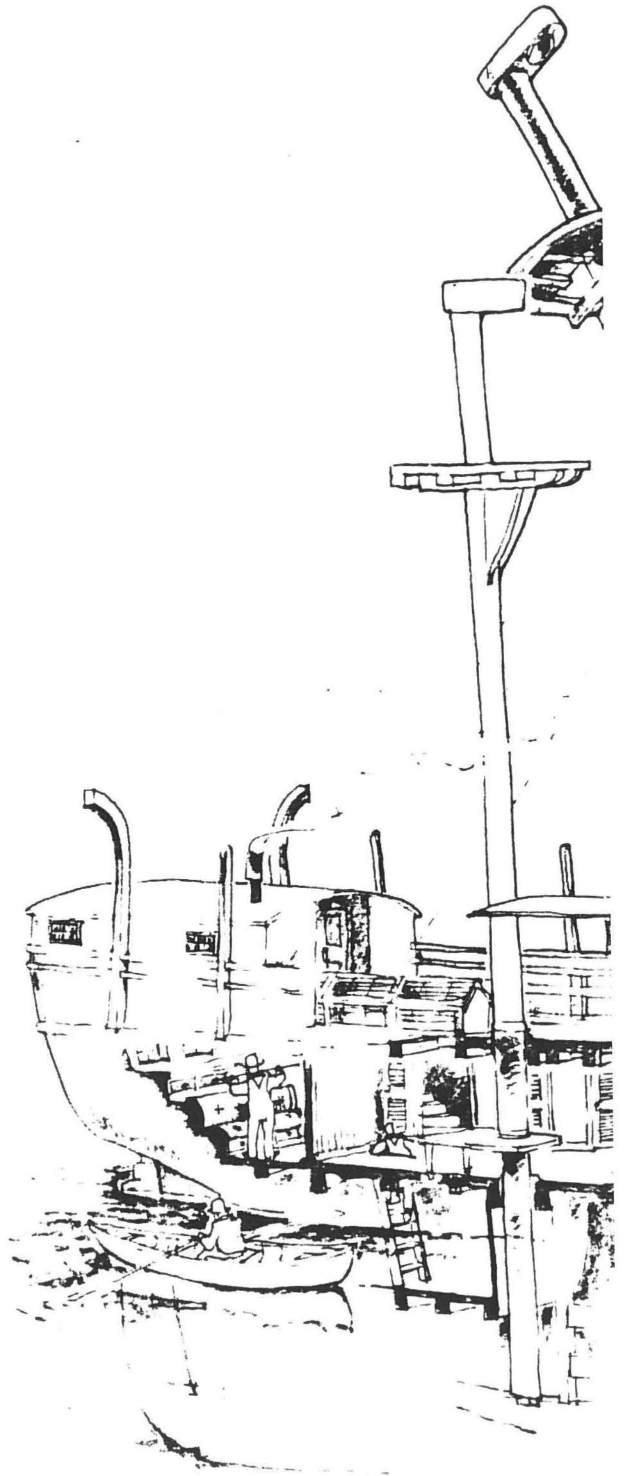
It is time to launch this ship. She is not ready for sea, but she is ready for the Acushnet River. The carpenters have been busy on her deck, fitting her out. The brothers Ingalls are pacing nervously, and even the stolid Knowlton seems to be chewing a little heavily on his cigar. The *ways* (slides) are greased and as soon as the *dogs* (wooden braces) are knocked away she will slide back into the river. There is still a lot to be done, but her identity is clear: across her stern in fresh gold leaf is a proud name, *Ulysses*.

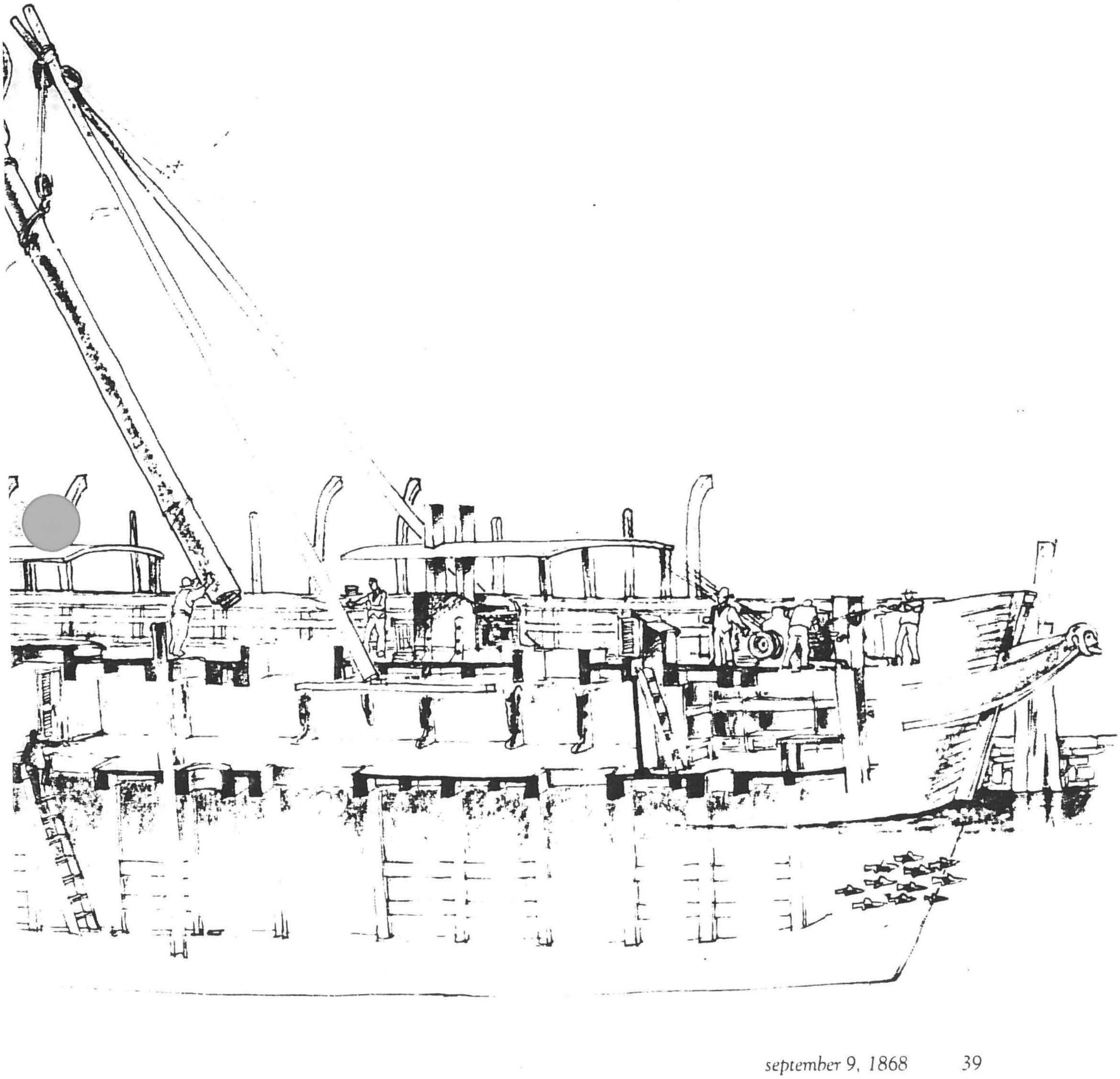
On the foredeck Albert and John Ingalls shake hands with Percival Knowlton, with carpenters and yardmen. The Ingallses say a prayer, Knowlton breaks a bottle of black rum over the Samson post, the dogs go flying, the slides screech and smoke as weight and friction set the grease afire, a wave from the stern, a gentle settling, and *Ulysses* is afloat.



Part of the wealth of the New World, of America when the English and French and Spanish discovered it, was in her enormous spruce trees. Towering and straight, they were perfect for ships' spars and masts. The trees for this ship's mast have been floated down from Maine, kept in the dirty backwater by the sewage outflow (where worms will not live to bore into them), and hoisted up into the spar shop. First they are roughed out, adzed to a general size with flat faces, and then they are turned on a spar lathe or planed with spar planes, smooth and round.

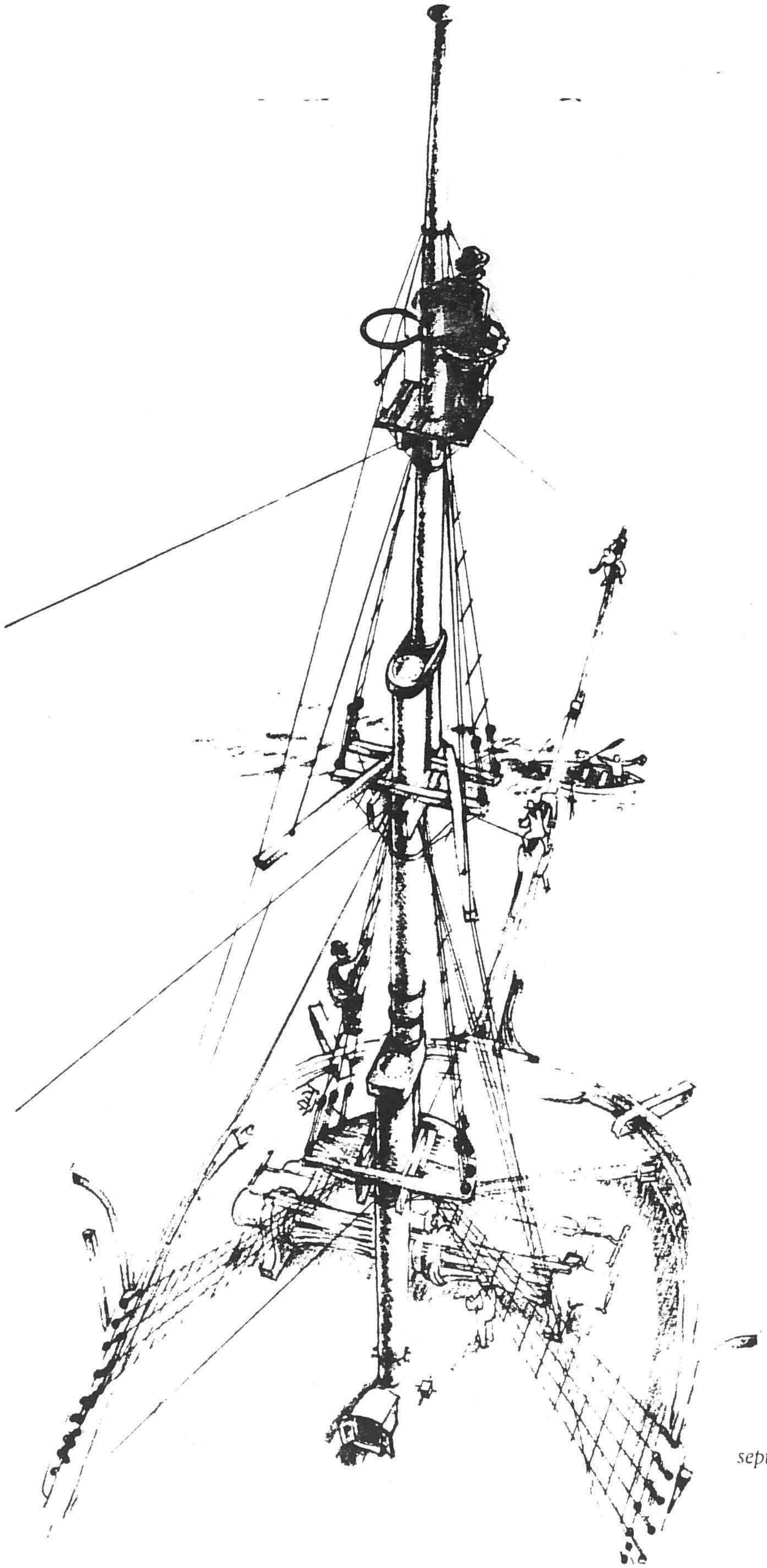
The foremast, mainmast, and mizzenmast are lifted onto the main deck and swayed down through with shear legs to rest on the keelson—each with a silver coin under its butt, just for luck. The rest of the spars—the topmasts, topgallant masts, and the yards—will be on the dock, waiting for the riggers.





Belowdecks the carpenters are fitting out the *fo'c'sle* (forecastle) forward, where the sailors will live; the living quarters aft for the mates and boatsteerers (harpooneers) and cook; and the elegant cabin for the captain.

Boss Pogany and his crew of riggers are swarming over the ship this week. Their business is tension: they are stretching tarred hemp line until it is "bar taut," holding the slender masts rigidly in place. From the chain plates at the sides of the ship the *shrouds* reach up to brace the masts from side to side. *Stays* brace them fore and aft. When the masts are secure the *topmasts* are rigged above them, and further up the *tapgallant masts* are rigged at a dizzy height. Between the shrouds the riggers have *bent on* (attached) small line that will serve as ladders—the *ratlines*. The *jibboom* is run out on the *bowsprit* and its heavy rigging is set up. The ship will have to be tuned like a guitar . . . a little more tension on the starboard mizzen-topmast shrouds, slack off on the main-topgallant stay, tighter on the martingale stay. Boss Pogany chews his mustache as he sways back and forth in the lookout's perch on the fore-topgallant mast, eyeing the set of the masts and feeling the tension in the shrouds. His men scamper in the rigging below like monkeys in the forest canopy, hoisting up the yards on their *halyards* and setting up the *braces* that will control them (and the sails on them, and the ship, and the voyage).



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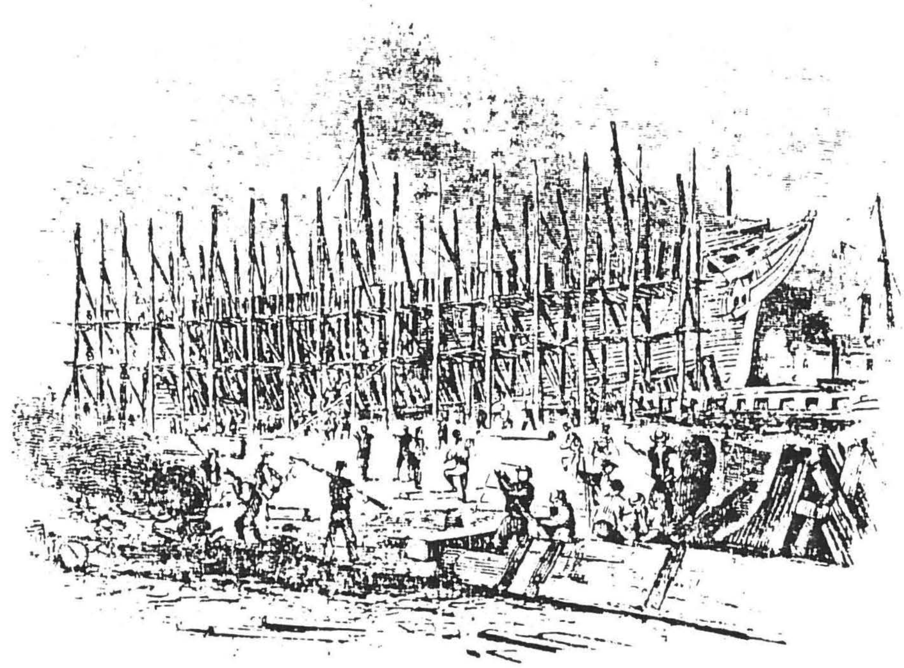


THE SHIP-YARD.

THE BUILDING OF THE SHIP.

WHETHER it was the example of the nautilus, or that of the broad-tailed squirrel, that first taught man to go down to the sea in ships, it is impossible to say. Only this much we do know—that the time has been when the race were as innocent of the navigation of the sea as they were of the air. Even within the time of historical record nations can be found who repudiated utterly the art of navigation as an impracticable thing.

The first ship upon record was the ark—a structure which, though built with high regard to the rules of construction, was not, as far as we have Scriptural history, preluded by other great vessels; and, what is stranger still, did not seem to teach the posterity of its builders any thing beyond the original coracles and rafts. Through thousands of years of attempts at navigation of the sea, it was reserved unto our own day to achieve any thing approaching to scientific control of the great waters, and the combination of beauty, safety, and speed in the ships that sail upon them.

With this short introduction let us together look through the ship-yards, and see the building of a ship.

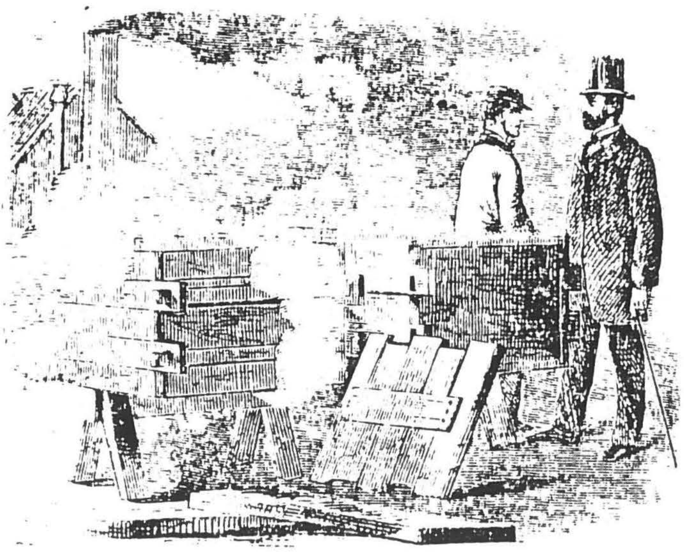
The first thing that will strike you, as we enter the territory of the ship-builder, will be the army of stalwart men, bronzed by the sun and weather, and armed every one with a broad, gleaming axe, which they fling with an apparent recklessness that bodes little safety to the groups of eager children who cluster about them, intent on filling their baskets with the scattered chips—realizing once again in our own day the poetry of the gleaners. You will observe that I said "apparent recklessness," for the hundreds of little snatching fingers and obtrusive toes need be under no apprehension. The blow of that axman is as true and certain as that of the Indian master of the sword, who cleft an apple held upon the open palm of his friend by one sweeping stroke without touching the skin. There are quite as marvelous stories told of these wielders of the broad-axe; of the feats they have performed; of their truth of hand and certainty of eye.

You will look over to your right, where, un-

AXEMEN.

der a shed, you will see sundry men performing strange movements, which, naturally enough, you will associate in your mind with those of the gymnast. We will approach nearer, when you will find that the half score of bowing men are *top sawyers*, bending in response to another half score who are in the pit below—the whole score spending their days in pulling this great-toothed saw backward and forward, through log and plank, to aid in putting together the wonderful structure that shall arise at our bidding.

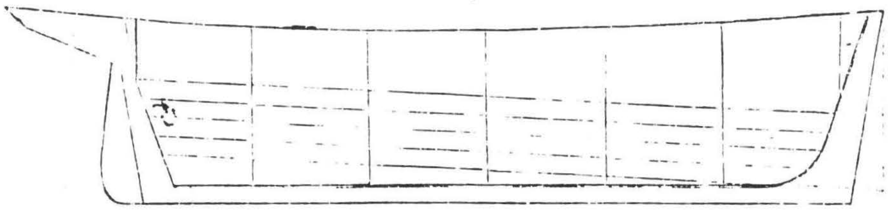
Cast your eyes over the left, where you will see an oblong box raised upon a frame a few feet from the ground, and about thirty feet in length. This is the steam-box; the receptacle of such pieces of timber as may be required especially flexible. To make them so they are inclosed within it for about an hour and a half, the steam is introduced, the timber is saturated, and is easily bent the required curve. Modern vessels require much less of this steam-box than those of a quarter century ago, being straighter in all their lines and larger in their proportions.



THE STEAM-CHEST.

Beside this steam-box is the blacksmith's shop, the forge whereon all articles of iron-work appertaining to the ship are made, excepting such as anchors, heavy chain, and whatever massive work may be beyond its limited calibre.

We will now cross the yard to the spot where our ship is to be built.



THE SHEER PLAN.

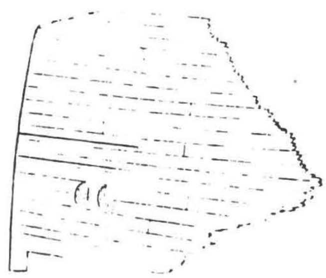
As you step occasionally over the great squared logs, can you not let your mind run for a moment back to the solemn, quiet woods where for centuries they dwelt and grew in grandeur, until one day the foot of a man rustled the autumn leaves beneath them? How he gazed up to the lofty branches and along the stout trunk! How he calculated the number of knees, cross-pieces, futtocks, and plank! How he laid his broad-axe to the noble tree, and, unresisted, hewed away unceasingly until the great dweller of the forest came thundering down, and was borne away piecemeal, that art may show what great works she can achieve! But we have no time to be poetical. We stand upon the spot where our task must commence; and yet before, as naval constructors, we can commence our work, we are dependent on the skill of the architect equally with the mason and the carpenter, who await his plans before the house goes up.

With a bit of chalk let me show you the duty of the naval architect.

The first duty to be performed is the making of the model. This is done by doweling certain thin pieces of cedar and pine together alternately, and from the mass so joined hewing out the form required. This model is from three to six feet in length, and is finished with the utmost care and precision. Upon this model each line of the future ship is carried out in miniature. The displacement of water is calculated, and the two great points for which the naval architect and constructor work are sought for. They are, firstly, that the stem and water-line should be so formed, that while they offer the least possible resistance to the water, they shall at the same time have great buoyancy. Secondly, this water-line must run with perfect smoothness the entire length of the ship, thereby insuring free action of the rudder and good steerage. In the attainment of these ends it is that all the science of the naval architect is lavished.

When this model is finished the naval architect commences his drawings. The first or principal drawing is called the *Sheer Drawing*. This is divided into three parts, called the *Sheer Plan*, the *Half-Breadth Plan*, and the *Body Plan*. To understand these drawings and the mode of making them, it is only necessary to imagine yourself called on at dinner to dissever a turkey without being posted in the ways of carving. As you will naturally do the thing wrong, allow me to suggest that, on the first slash of the knife, you will divide Mr. Turkey in two parts, from the neck to the pope's nose. That is the Sheer Plan. Or, as there is more than one way to do the thing wrong, we will suppose that you see fit to divide the bird by cutting him in two parts, equidistant between those extremes of its person mentioned above. This would be the Body Plan; while by laying it upon the side and slicing it through lengthwise, you will get the Half-Breadth Plan.

From this sheer drawing we, as practical builders, go to work and make construction drawings, which shall show the exact position of every plank and timber in the ship we are about to build. The end gained by this proceeding will be, that every plank and timber can be accurately cut according to the shape wanted, and when brought to its place on the growing ship, can be fitted with little or no trouble. To show



this, I here give you, with a few touches of my chalk, a portion of the outer planking or skin of a ship, according to the construction drawing, that you may see how easy it is, by reducing feet to inches and inches to hundredths, to get out each plank of the required width, length, and thickness to cover certain places.

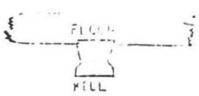
THE HALF-BREADTH PLAN.

We can now begin hewing out our ship, and if we please putting her together until she looms up to the very skies, and if we do not please, we can number our timbers and planks from one to twenty thousand, and send them to Japan or Patagonia, where they shall, by competent hands, be put together, making a stately ship that shall carry the Japanese or Patagonian stars and stripes all over the world.

If we conclude to make this ship here, we must prepare blocks whereon to lay the keel. This is a simple matter, being only the placing of short, thick pieces of timber, so arranged as to allow for the declivity of the ship, which is equal to ⅝ths of an inch for every foot of her length—this inclination being made, as I shall hereafter show, for the purpose of launching.

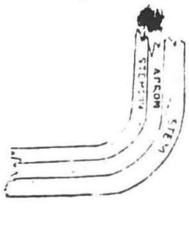
We now proceed to lay what is termed the *First* or *False Keel* of our ship, being pieces of wood from four to six inches in thickness, and of the same breadth we intend our keel to be. Elm is the best wood for this purpose, seasoned by immersion in water rather than exposure to air. The object of this false keel is to prevent the ship making lee-way when sailing upon a wind, or should she go ashore, to relieve her by forcing it off and thereby lessen her draught of water.

We come now to the laying of the keel, which, supposing we are about to build a first-class ship of 2500 tons, will be composed of pieces of timber about twenty inches square. As one piece of timber will not stretch the length of this great ship, some certain means must be found to join them. This is done by *dowelling*.



I have said that the keel is a piece of timber twenty inches square; but I will make a reservation in this so far as to say that a groove is cut through its whole length on either side, just deep enough to receive the planking.

Our keel being laid, it becomes necessary to go on and set up our timbers, the most important of which is the *stem*. The stem of our ship is of the soundest and most solid pieces of oak we have in the yard. Pieces, I say, for the reason that no single piece can be found of sufficient size to make the stem. We therefore, by our doweling, or *scarphing*, as it is termed, join together three pieces to make the size required, allowing the top, or piece farthest away from the water, to be somewhat the largest. Directly behind this we place another piece, which is doweled to the stem and denominated the *apron*. Once more, behind the apron we place another timber, which we call the *stemson*, intended to strengthen the stem. These three pieces, acting one upon the other by the aid of bolts, dowels, and scarphing, form a solid mass of timber calculated to resist heavy thumps, and, if need be, walk through an iceberg.

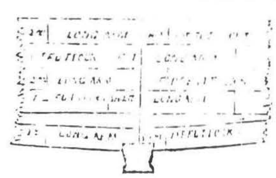


Having that important part of our ship erected, we will turn our backs upon it, and proceed to put up our stern-post.

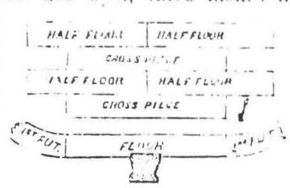
The *stern-post* is—if timber can be found sufficiently large—in one piece. This is a matter of vital importance, from the necessity of great strength, the stern-post being the piece whereon the rudder hangs, and on the safety of which the very existence of the ship depends. This also is of the most solid oak, and is grooved, like the keel and stem, for the reception of planking. The fastening to the keel is made by teeth in the post, fitting into a mortice in the keel. To strengthen the main-post there is also an inner post doweled to it, as in the stem, making a solid combination of timber of such size as can not be had without joining. In the round stern ship timbers are worked out from this stern-post to form the shape required, and are called post-timbers.

We will now proceed toward setting up the frame of our ship, or that portion of the structure that gives it form and shape. This frame will be a numerous family of timbers, rejoicing in the names of cross-pieces, futtocks, top-timbers, floors, half-floors, short and long armed floors, and a few others too tedious to mention, and not at all necessary to our work. We will repudiate all technical terms, and go on with our building or laying the floor.

The floor of the ship is composed of square timbers, laid at right angles across the keel, and fitted to it by a groove. These timbers are not laid upon the keel with an equal balance, but reach alternately to the right or left; whichever end reaches farthest from the keel being termed the long arm, the other end of the same timber, on the opposite side of the keel, being called the short arm.



Another method of laying the floor, or rather what is termed the half-floor, is by a cross-piece laid equally upon the keel, and two timbers meeting on the middle line. For the purpose of making these half-floors and cross-pieces like one solid piece of timber, dowels are used, three inches in diameter, and sunk one and a half inches into both cross-piece and half-floor, and then secured to the keel by bolts.



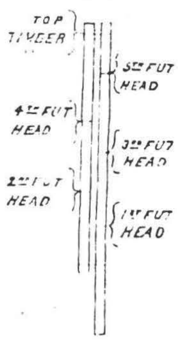
We have now reached that point of our labor where we are about to raise our ship above the keel. We are about to handle those important timbers called *futtocks*. These, when elevated to their proper positions, will make the frame of the ship, and will much resemble those ana-

tomical preparations of the human frame which you have possibly seen in some doctor's office or museum.

The futtocks are straight or bent timbers, as the curves of the ship may demand, and are fastened with a dowel upon the end to the end of each half-floor, cross-piece, or arm, carrying up the sides of the ship to the required height. According to the position in which they are used they are termed first, second, third, and so forth, the first and second futtocks being nearest to the keel. To explain this still more minutely, let me say that the first futtocks are attached to the ends of the half-floor or the long arm; the third futtocks on the ends of the first futtocks; the fourth futtocks on the ends of the second futtocks; and the fifth futtocks on the ends of the third futtocks.

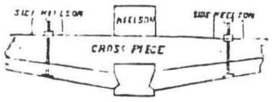
In the building of the ship, after speed is considered, lightness, which is the parent of speed, must be sought, as by attention to that point the carrying powers of the ship will be increased.

To insure this lightness we must use as little timber as possible consistent with strength, every stick of the frame being set at such distance apart as will admit of this strength. Three feet nine inches is the regulated distance in which shall be placed one cross-piece and one floor or half-floor, with the futtocks necessary to carry up the frame. This section of the ship, as here chalked out, being put together on the ground and hoisted to the required position on the growing vessel by means of sheers or tall masts with necessary tackle. Now these floors and futtocks must vary as the building of the ship approaches the stem or stern. This is done by cutting off the floors, as well as giving them a greater cant upward, that they may meet the futtocks, which, as they approach toward either end of the ship, have a greater desire to run straight up, making the ship at those points more of the wedge form.



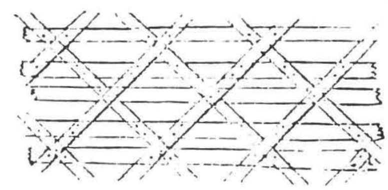
As all these futtocks are raised to the places they are to occupy they are *shored up*. Shores are sticks of timber acting as props to keep the sections of futtocks in their places, the upper end resting against the ribbon or piece of wood fastened temporarily across the futtocks for the purpose of staying.

Our stem, stern, and side timbers being all up, the next job must be to introduce the keelsons. The principal keelson is a piece, or pieces, of timber joined the same as the keel and laid directly above it, acting as a strengthener of the vessel lengthwise and as a means of securing the floors in their proper places. The keelson is laid directly over the keel from stem to stern, and secured by copper bolts driven through the floor and keel, and by wooden dowels to the floor. Besides the main keelson there are side keelsons, sometimes two, and sometimes four, according to the size of the ship, secured through the floors, futtocks, and outer planking. These side keelsons not only aid in making the ship more strong, but in staying for the timber that makes the stepping of the mast.



Another important point is the filling or closing of all space between the futtocks and below the water-line with timber. This is done that the ship may still be water-tight should she chance to strike upon rocks or ground, and tear off her outer planking. These timbers are fitted closely in the open spaces between the floors and the futtocks, and are well calked before either outer or inner planking is put upon the ship, making her so that without any out-side planking whatever she will still float.

The next point is of the internal trussing or bracing the ship with iron. These braces or trusses are bands of iron from three to six inches wide, running across the timbers at acute angles from the side keelsons to the upper timbers and fastened to them by bolts. These tend to give



the frame great strength; in fact, if properly applied, making it impossible for the ship to go to pieces or to become what is technically termed *hogged*—a difficulty produced by the falling of the stem and stern and the rising of the keel, making it curve, and destroying the sailing properties of the vessel.

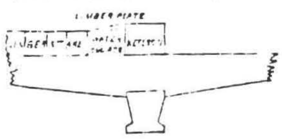
We have now the frame or outer shell of the ship ready for her decks. These decks will be in number according to the size of the ship. For one of the size we are now building three decks will be necessary, which we must put in as the carpenter puts in the floors of his house. We first, at the height we intend these decks to be, run a rib of timber longitudinally the whole length of the vessel, securing it to the side timbers by bolting. This is called the *shelf*, and on it rest the beams that stretch across the ship, on which beams the floor of the deck is laid.

The same rule that applies to the keel, the stem, and the stern-post applies equally to all these vast timbers, whether they be shelves or beams: they must all be joined and made up from small pieces by scarphing or doweling, or

both. These beams, as well as the shelf, are made from the very best of pine, and the deck planking of the same wood, taking care to select it as pitchy as possible.

In speaking here of decks I do not mean to say that we must lay them yet. There is other work to be done first. We have the frame all up, trussed, and bolted, and now we must draw the *skin*, as it is termed, over the ribs of the great monster and put in the timbers and inside ceiling.

This inside planking, which is generally worked on at the same time as the outside or skin, is called the *limber strakes* or *ceiling*. The limber strakes are a little over half the thickness of the keelson, and are worked on to the futtocks inside, in the same manner that an ordinary room floor is laid, with iron or copper bolts reaching only into the futtocks, not through them. Between the keelson and the first limber strakes an open space or gutter is left, called the water-course, intended as a conveyance for whatever water may find its way into the ship from leakage to the wells, that the pumps may get at it. It will be the intention of the ship-builder with these limber strakes or inside planking to make them as tight upon the seams as he would outside plank, so that in the event of any injury to the skin of the ship leakage would not ensue. In small vessels it is upon this planking and upon the skin that the steam-box is mostly brought to

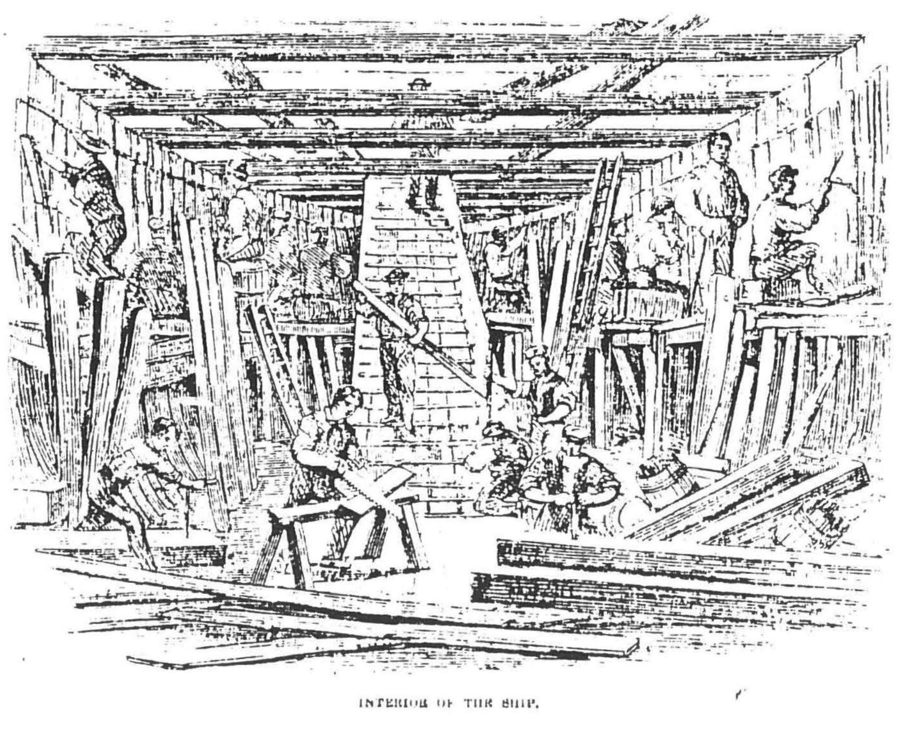


bear, that the timbers, especially those of the forward and aft parts of the ship, may be easily bent to the required curves. In a ship of the size we are now building, the lines being so near straight in comparison to the shortness of the pieces of strakes or plank, the steam-box is of little use.

And now we will proceed to put the skin upon our ship, premising a few words upon the difference between English and American modes of planking. The English ship-builders, in planking a ship's bottom, use both English and Dantzig oak, with sometimes fir and elm, below the water-line, on account of its non-liability to split. The English oak being cut from trees largest at the lowest end, the planks come out in such shape as to make it imperatively necessary that the builder, for the sake of saving much stuff, must use them in this angular style. The American plan differs from this in so far that we always use straight outside timbers, except in such cases as where the form of the ship demands otherwise.

Before putting the planking upon the ship it is the duty of the master-builder to see that his frame stands perfectly true and perpendicular. If it should not do so, he must slacken his shores and ribbons on the one side, and tauten them on the other, until that end is attained according to the plumb-line.

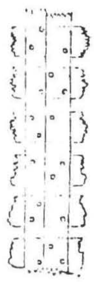
These outside planks, or skin, in a ship of the size we are now building, vary in thickness from four inches to ten, the thickest plank being



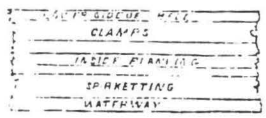
INTERIOR OF THE SHIP.

about the wales, or that part of the ship above water, and just below the line of the first, or upper-deck. There is no part of the building of the ship requiring so much care and judgment as does this putting on the skin. Any error in selecting the material, or in bending it wrongly, may cause splits or bruises that eventually, by leakage and decay, may endanger the very life of the ship. As this planking approaches the stem or stern it is thinned off, to admit a more easy bending and fitting to the curves and to the rabbet of the stem and stern-post.

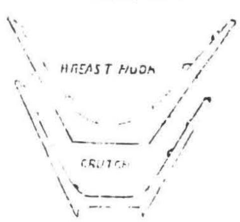
The fastening of this skin to the futtocks, or frame, is done by wooden pegs of locust, called *tree-nails*, the holes for receiving which should be bored several days previous to using, that the sap remaining in the wood may thoroughly dry out. The tree-nail is then introduced, by a plan called double and single fastening—being the alternate driving of one and two tree-nails into each futtock.



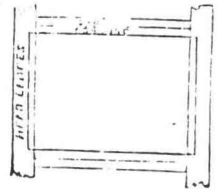
The next item for consideration is the *water-ways*, an internal hoop of timber, passing longitudinally along the ship, just above the decks, serving the same purpose on top that the shelf serves below. The inside planking just under the lower side of the shelf is called the *clamps*; and the same, just above the *water-ways*, the spirketing. Both the clamps and spirketing are more strongly fastened to the timbers of the frame than any other part of the ceiling, that they may lend their aid to the support of the shelf, water-ways, and beams.



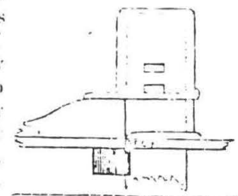
Before I go farther, let me say a word in reference to *breast-hooks* and *crutches*. These are timbers or iron, as the choice may be, intended to unite the ship together at both stem and stern, where the floors do not cross the keel. When used forward they are called breast-hooks; when aft, crutches. They are intended to fit upon the keel, stretching out their arms, which are bolted to the side-timbers. They form a part of the general system of strengthening the ship.



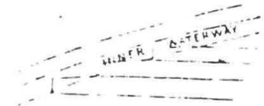
We come now to the laying of the deck—or, as technically termed, the *framing* of the deck; the marking out the hatchways and openings, the most important of which are the mast-holes. These mast-holes are always made from three to six inches larger than the masts that are to go in them, the overplus of space being arranged by the insertion of wedges, which keep the mast in its proper position. The frame about the mast-hole is composed of fore-and-aft partners, cross-partners, and corner chocks. The hatchways are formed square-oblong, the broadest part of the opening running across the ship.—The fore-and-aft pieces are called coamings, while those athwart-ship are called head-ledges.



Included in the framing of the deck are the *riding-bitts*, which are intended to receive the cable when the ship is lying at anchor. It is usual, on a ship of the size we are now building, to have two pair of riding-bitts or four. These bitts, for their better security, run through two decks. Sometimes the riding bitts are dispensed with, and the windlass, of which I shall speak presently, is used instead.



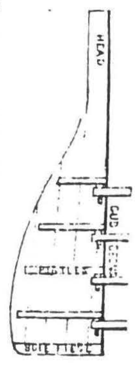
We have nothing now but to lay our deck, which is a simple work—care only being had, in putting on the outer planking, or skin, to bend and fit the plank well and carefully, avoiding all flaws and strains, that the decks may be perfectly tight, without a chance of springing or straining from the fastenings. There must be next to the water-way a single plank, laid down and fitted into a rabbet in the water-way, and then gradually cut down on the outer edge until it meets the deck plank; this is called the inner water-way.



Upon our ship we shall put three decks—the upper deck, the main deck, and the lower deck; but in vessels of war the names of decks are numerous beyond mention.

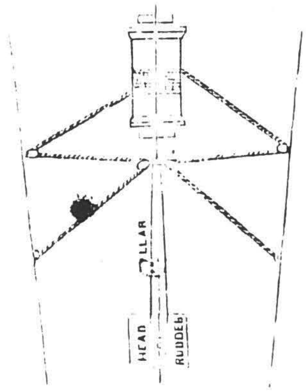
The most important parts yet to be considered are the rudder, the wheel, the capstan, the finished bow and stern, and the calking and coppering of the ship.

The *rudder* is the instrument used to guide the ship—the brain of the great mass. On the construction and proper hanging of this portion much depends. It is made from the very best of oak and elm, the head being round, while at its foot is worked a piece of plank about six inches thick, so that should the ship touch ground, this *sole-piece*, as it is called, will come away, like the false keel, and perhaps free her. The rudder is hung to the ship by pintles and gudgeons, the first attached to the rudder, the last to the stern-post.

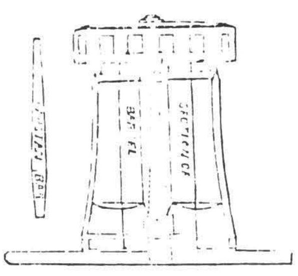


Our rudder being now hung, we will turn our attention to the wheel—the power that holds the rudder in subjection.

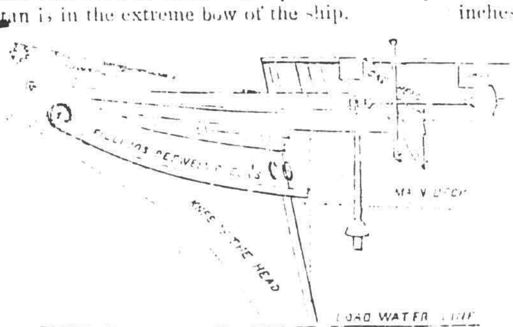
When the rudder is hung, the circular head coming above the deck is morticed to receive the tiller, or piece of wood intended to act as a lever in forcing the rudder to the right or the left, as circumstances may demand. Attached to the end farthest from the rudder-head are the tiller-



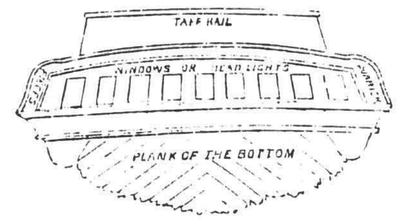
ropes, running through small blocks, and from these upon one end to the side of the vessel, upon the other to the barrel of the wheel, where it is wound seven times about the barrel, so that the barrel, upon being turned, shall slack upon one rope and haul taut upon the other. By this means a power is gained by one man that with the tiller alone could not be gained by four.



The *capstan*, or windlass, in a vessel of our class, should be double, running through two decks, and having two barrels, that two sets of men can work at once. The place of the capstan is in the extreme bow of the ship.



THE BOW.



THE STERN.

And now the artist must explain the bow or head of the ship, and her stern.

We now have our ship, only excepting calking and coppering. The first is generally done upon the outside skin while the ship is upon the stocks; but the inside timbers are often left uncalked until the ship has been several years in use, as it is supposed that as calking tends to stiffen the fabric of a ship, the inner calking comes to her aid in that way after she has been racked and strained.

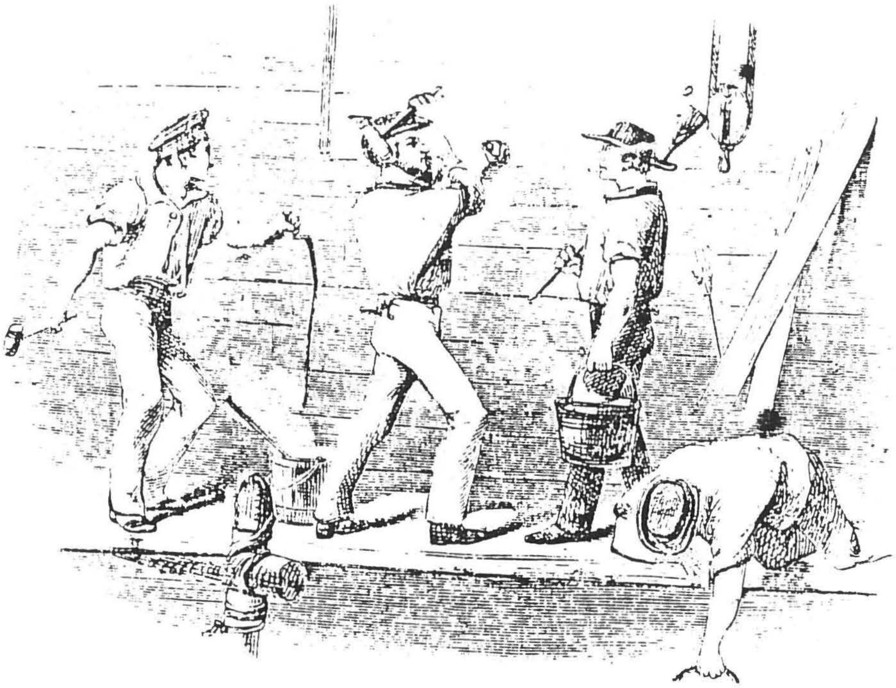
Calking is the making of the seams impervious to water, and is accomplished by forcing into them, with sharp iron wedges called *calking irons*, oakum, which is old rope, cut into short pieces and picked into threads. After these seams are all filled melted pitch is put over them with a small broom. A mixture is then made of pitch and tar, which is spread over the entire bottom of the ship, as far as the copper is intended to come, as smoothly as possible. The decks are calked in a similar manner, but instead of pitch, marine glue is used to close the seams.

We have now our ship ready for the copper. In many cases this coppering is not done until after the ship is launched, perhaps not until she has made several voyages, when she is taken out upon a dry dock, calked and coppered.

It was not until the beginning of the present century that copper was used upon the bottom of ships, previous to that time a coating of pitch and tar being thought sufficient protection. The clogging of the ship's bottom with vegetable matter, and the ravages of the sea-worm, soon taught the mariner better, and copper sheathing was the result.

It is customary in coppering a ship to use sheets measuring four feet in length by fourteen inches in breadth, and weighing from twenty to thirty-two ounces per superficial foot. These different weights are used upon the same ship, the heaviest about the bows and along the load water-line. A ship of the size we are now building will require about five thousand sheets, weighing a fraction over thirty thousand pounds.

Having reached that point where our ship is ready for launching, let us proceed to launch her. But do not deceive yourself with the idea that our ship is ready for sea; she must first go into the hands of the spar-makers and riggers. We have built the ship; the riggers' duty is



CALKING.

foreign to us, however important it may be to the ship. Therefore, while all things are getting ready for the launch, lend your ears while I speak a few words with regard to ship-building timber.

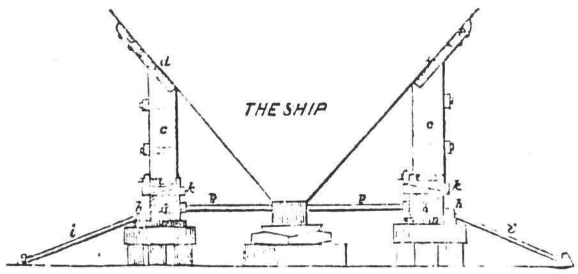
In our country little is used but oak and pine; but in England experiments have been made in almost every wood under the sun, and the general conclusion has been reached that East India teak is the best. The great difficulty to be overcome is the decay of the timbers with dry-rot, or fungi that grow and extract all the juices of the wood until it crumbles away under the least pressure or strain. Merchant vessels are more subject to this than men-of-war, ventilation being the only means to arrest its progress. By the Marine surveying laws, a ship is only allowed to remain on the first-class list twelve years, it being calculated that in such time decay has well advanced. Cases have been known where a well-built oak ship would in a few months be useless from dry-rot.

The comparative qualities of wood, according to the English valuation, for ship-building are: *First*, Teak, mahogany, pencil-cedar, Spanish and French oak. *Second*, Red cedar, white oak, and Spanish chestnut. *Third*, American oak, chestnut, larch, tamarac, pitch-pine, and ash. *Fourth*, Red pine, elm, birch, spruce, and beech. *Fifth*, Hemlock. American builders place our oak higher.

Experiments on the power of timber to resist crushing, breaking, and pulling apart, show that yellow pine withstands a pressure of 5375 pounds to the square inch, ash 8683 pounds, oak 9509 pounds; while the cohesive strength of ash is 17,000 pounds to the square inch, and oak 10,000 pounds. A stick of oak, 8 inches by 12, and 15 feet in length, required a weight of 19,153 tons before it would break. Many experiments have also been made with timber to prevent its decay, sometimes by immersion in liquids, sometimes by drying it in ovens and kilns, and sometimes by injecting chemical substances into its pores. The process of salting timber has been in use for over half a century, and is perhaps the only real practical preserving that has yet been done. Corrosive sublimate, chloride of zinc, sulphate of copper, and kreosote, have all been used with certain success in saturating the fibres of the wood; and timber has been subjected to currents of heated air of 114° Fahrenheit, which reduced its weight 20 per cent. in sixteen days; but with all the success of these experiments none of them have been brought practically to bear in the building of the ship.

Now for the launch. We have a mass of timber, copper, iron, etc., weighing somewhere about 3000 tons, which we are anxious to get into the water with safety to ourselves and it.

As a representation of our ship's bottom I will give you an angle, in looking at which you will be kind enough to imagine that you are standing at the bow of the vessel and looking down her length. I have before mentioned that the keel of the ship is laid on a declivity of $\frac{5}{8}$ths of an inch to a foot; and now, in our efforts at a successful launch, it will be necessary that we

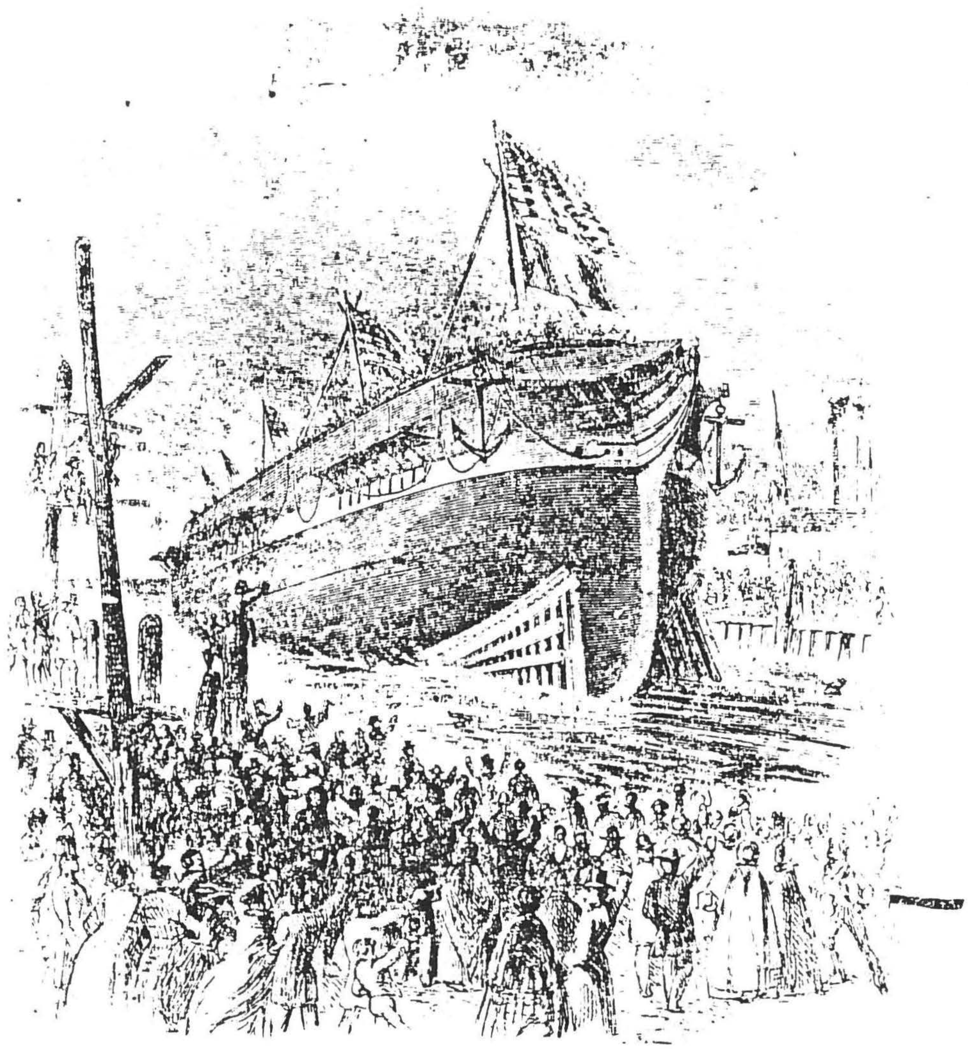


should give the sliding ways, or plane upon which she is to glide into the waters, a still greater slope. We will even go so far as to give them $\frac{7}{8}$ths of an inch declivity to each foot of distance. The smaller the vessel the greater is the declivity, much depending on the weight of the mass moved in making its own momentum.

These *sliding ways*, which I shall mark *a*, are smooth plank laid upon heavy timbers, forming a continuous line from the ship to the water, and are laid when the tide is low that they may reach far out. Upon these sliding ways rest the *bilge-ways*, marked *b*, much as the runner of a sled rests on the snow. These bilge-ways, which are about $\frac{5}{8}$ths of the length of the ship, and connected with her by certain upright timbers—*c*, called *poppets*, and others called *stopping up*, the latter of which are used amidships, the poppets before and abaft. The poppets are confined to the side of the ship by a plank, marked *d*, which is bolted to the ship's side, and farther strengthened by cleats, *e*, which are also screwed to the bottom. The lower ends of the poppets rest upon a plank, *f*, called a *sole-piece*, which is placed on the upper side of the bilge-ways, the sole-piece having a groove taken out of it to receive a tenon cut in the lower end of the poppet. We have now to provide for these bilge-ways keeping the track when once they begin to move our ship along the sliding ways and toward the water. This is done by placing a timber, called a *shore*, marked *g*, from the keel of the ship to the inside of the bilge-ways: this prevents the bilge-ways slipping inward, while a strip, entitled a ribbon, will prevent them going outward, nailed along the sliding ways, and secured from any chance of being forced away by a shore reaching from its outside to the ground marked *h* and *i*.

This is the outline of the machinery of the launch. The additions must be made at the time of launching in the shape of wedges, grease, and soft soap. The wedges used are two upon each poppet and are called *slices*, marked *k*. They are inserted between the sole-pieces and the bilge-ways, and, just previous to the hour of launching, men are stationed at them with mallets, who, driving these wedges, raise the huge mass just sufficient to allow the blocks upon which she was built to be removed. This removal is made with all the blocks but those in the foremost part of the ship, which are split away piecemeal, and the great structure rest upon the cradle confined only by a single piece

COPPERING.



THE LAUNCH.

of timber called a *dog-shore*. This dog-shore holds her back from slipping away into the waters by being placed on one end against a secure point on the ship, the other against a cleat on the bilge-ways. To it there is affixed a trigger and a string that, on the word being given, the dog-shore may be pulled away and the ship be free. Only one thing is necessary, which is to see that the sliding ways and the under side of the bilge-ways are well covered with grease, oil, or soft soap, that the least possible friction may ensue, and the stately ship go smoothly into her future home.

All is now ready! The gorgeous banners and gay streamers are floating and fluttering from every available point. The decks are crowded with happy people. The crowds stand in hushed and breathless expectation. The work is done, and not even the click of a hammer is heard, nothing but the ripple of the full flood-water that breaks up to the shore, struggling as it were to kiss the great ship that is so soon to nestle upon its bosom.

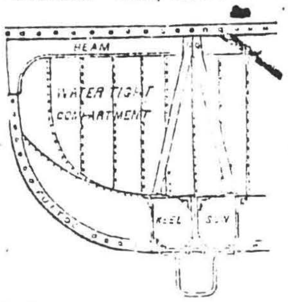
A fair creature, "God's last, best gift to man," comes forth from the group upon the deck, with a flushed cheek and a sparkling eye, and casts the christening wine against her bows, calling the ship aloud by the name she shall henceforth bear. In an instant the stout voice of the builder is heard ringing over the rail, "Down, dog-shore!" and to the music of a thousand shouts the grand ship glides away with a laughing plunge into the element in which she is to make all her future conquests, whether they be of war or of commerce. Hurrah!

Once more let me, even though we have our

wooden castle finished and out upon her mission, recall your attention to ships. This time I desire to say only a few words about iron ships; and I shall not detain you long, for the very simple reason that the general theory is the same as in wood, making only the difference that, while in large vessels it is wrought in pieces, and the

floors and futtocks laid upon and from it, in the smaller the keel is merely a

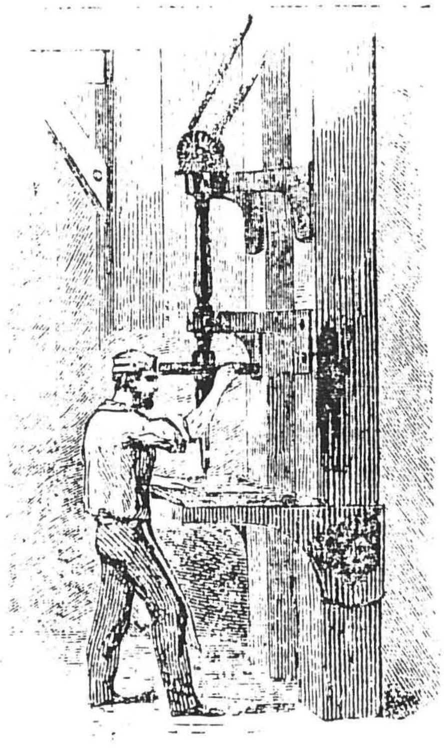
groove made upon the bottom plate by subjecting it to pressure in a mould while hot. Still, with the aid of my chalk, I will



illustrate this fact, and also show you the sectional form of the floors, futtocks, and keelsons.

The building of the iron ship is in every respect the same as the making of the steamboat boiler. The iron sheets only differ in quality, the boiler iron being much the best. These sheets vary in size, according to the calibre of the vessel, but the usual size is three feet by nine. In thickness they vary greatly, ranging from half an inch to seven-eighths, and of course heavy in proportion.

Upon the construction drawings being made for an iron ship they are dispatched to the foundry, and each plate is got out the exact required size. The best of this plate is made in the Pennsylvania foundries, and upon reaching the spot whereon the ship is to be built, requires only the preparation of bending, and punching for the rivets before being added to the frame. To achieve the bending the plate becomes, for a sufficient space to give it a fine red heat, the tenant of the furnace. From its fiery bed it is dragged forth upon a heavy iron floor, where, under the hammers of the moulders, it is brought

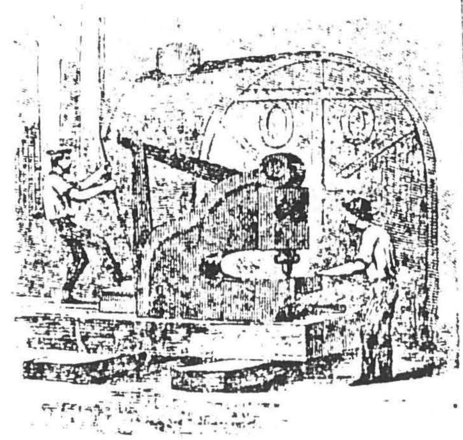


DRILLING MACHINE.

to whatever curve may be required. The next move is to send it through the punching machine, the powerful machinery of which, worked by two men with the aid of steam, cuts a line of holes about its edge, three-quarters of an inch in diameter, with about the same ease that a healthy Miss of twelve would send her teeth through a slice of bread and butter. After this preparation the sheet is ready to become part of the vessel, and is riveted to the sheet that has gone before by overlapping, the rivet being driven from the inside, a second workman on the outside clenching it. In small vessels rivets are used to confine these sheets to the frame, but in large, bolts, the holes for which are drilled by a machine also worked by steam-power, and eating through the iron with a certainty calculated to give you a pain in the bones with the mere idea of your being a piece of iron.

This out-side sheeting is graduated in thickness from the keel up, the thickest and best iron being nearest the keel. In small vessels the outside sheeting generally constitutes the ship, perhaps with the addition of inside wood planking; but in large vessels the outer sheeting is precisely the same as in wooden ships but half the covering of the frame, the inside being covered in a similar manner, making, as it were, one vessel inside the other.

Another matter worthy for consideration is the method followed in iron ships of dividing



PUNCHING MACHINE.

into water-tight compartments. The number of these will vary according to the size and capabilities of the ship, each compartment forming a complete floating vessel by itself. The advantage gained by this is, that any accident occurring by which the ship leaks, no matter to how great an extent, she will still float, the water being confined to that compartment in which the injury originated. A notable instance of this can be adduced in the case of the iron steamer that came in collision with the *Arctic*, of the Collins line, the great wooden ship sinking in a very short time, while the iron one, with injuries greater in proportion, floated and found her way to port. These compartments are made simply by partitioning the ship, leaving only openings for the doors, which are made to close with such nicety that all chance of the water making its way past the part it came in on is cut off. This partitioning is done the same as the outer or inner sheeting. Many suppose that an iron ship is all iron. This is a mistake, wood entering into her composition largely, sometimes even to the large part of the inside fittings, beams, decks, and, in fact, every thing but the mere shell of the ship.

And now, my friend, thanking you for your kind attention, and having some conscientious whisperings that I may bore you should I continue, allow me to lead you gently back into the flowery paths of private life. Do not despise this little lesson, for who knows how useful it may be to you yet! Look abroad, you will see your countrymen all over the world showing every body how to do every thing, and perhaps it may be your mission to follow in their footsteps. Who knows! If in the future it should be necessary for you to build a steamer for the Emperor of Timbuctoo, or a ship of the line for our ally the King of Madagascar, remember that we laid our first keel together; and so *au revoir*, which in American is equivalent to throwing an old shoe after you.

CALICO AND CHATTERBOX.

"DO you know, Uncle Frank, that I do not admire your writings?" abruptly remarked my niece, Annie, as one evening I prepared to assume the pen.

We were sitting at the evening table. I was smoking, and Annie, my favorite niece and housekeeper, was busying herself with some fancy-work—that is, she was industriously stitching a bit of white linen, ornamented with blue lines fantastically entangled, like the trailings of morning-glories on the lattice of the old homestead in the country, while here and there, at regular intervals, were perforations which looked extremely like the eyes of fishes, with lids that never shut, staring at you with all their might, as they do from off the marble slabs in Washington Market. For what mysterious purpose the wonderful fabric was intended probably young maidens best know. I have found upon experience that it is not always wisdom for an old bachelor like myself to suggest innocent inquiries to the "muslin denomination" concerning aught more intangible than a "Havelock," or the unmistakable contour of the sleeve of a "shirt," I being invariably rebuffed by the curt remark that "Gentlemen should not be inquisitive," and "Old bachelors should never ask any questions."

I am an old bachelor, coming forty next May. Threads of silver are already streaking through my black hair. I have never married because I have never found that a wife was indispensable to my happiness; being blessed with plenty of nieces every way accomplished and capable of superintending my limited establishment. I live very quietly, because it suits my taste; yet I like to see my nieces enjoy themselves, and am always happy to receive their friends, that is, to have them receive them, while I smoke my quiet cigar and scribble away in the back parlor. I have ever regarded my pen as my confidential companion, and have rarely felt the need of any other. It may be selfish to live thus, but I have found it so far extremely pleasant. I see quite enough of the world at my office in town, and going to and from it, to give me an agreeable relish for the quiet of home.

I was startled by the expression of such a decided opinion from the lip of my usually quiet and amiable niece. She, to suddenly assume to criticise me, after I had won the reputation in the literary world of "being above the mass!" The remark annoyed me; though the opinion of a young girl like her—what of it? Probably the little sauce-box said it just to plague me—to draw me out, and make me say something to beguile the monotony of the long evening hours, which, to her, with her interminable fancy-work, perhaps were tedious. Of course her opinion was naught when weighed in the balance of my greatness; but turn it which way I might, it was an opinion still, and a pretty decided one, from a representative of the mass of womankind. Then arose three mighty questions in my mind, three as knotty and perplexing queries as vexed St. Leger, while solving the Enigma of Life: "*What are we? Whence are we? Whither do we go?*"

But mine were:

I. Was it judicious to ignore a woman's opinion?

II. Do not women constitute nearly or quite half of the readers of our magazines?

III. Why should not we defer to them and to their tastes? Their keen intuition often leads them directly to the Right, while we, vaunted wise men, go struggling on through the circuitous by-paths, ever seeking fitful glimpses of the goal which they at once descry.

But the idea of consulting my very commonsense niece about my literary affairs had never before occurred to me, though I was perfectly willing to confide to her superior judgment, young as she was, the most important considerations of actual life, knowing that they would be quite as faithfully attended to as if I, in my

Chapter VIII

Describing the Different Parts of a Ship Constructed of Wood

In this chapter I shall describe and illustrate the principal parts of a wooden ship's construction, explaining the position each occupies, its duty, and how it is shaped and fastened.

8a. Explanatory

The longitudinal form of a vessel is determined by timbers called the keel, the stem and the stern-post. The stem, which is at the foremost extremity, is supported by its combination with the keel, which is the lowest part of the structure, by other timbers lying in its concave part, called the apron, and the stemson; the apron and stemson unite with timbers called the deadwood and with the keelson, which timbers strengthen and give support to the keel; the stern-post, which is at the aftermost extremity, is supported by timbers called the inner stern-post and the sternson; and these timbers likewise form a junction with the keelson, deadwood, and keel, so that a mutual connection is kept up by them, to preserve the longitudinal form.

Transversely, the form is given by assemblages of timbers placed vertically, called frames. The lowest timbers of the frames, called floors, lie between the keel and keelson, extending equally on each side; the other timbers of the frames, called futtocks and top-timbers, connect keel to the timbers that form the upper boundary of the structure, which are called gunwales and plank-sheers.

The longitudinal form is further maintained, and strengthened, by exterior and interior linings, called planking, and by interior binders, called shelf-pieces, which are united to the frames. The exterior lining or planking which is connected with, and covers the whole surface of the frame, is made watertight, to preserve the buoyancy of the body. The two sides are connected and sustained at their proper distance apart by timbers lying horizontally, called beams; these are firmly united to the sides of the ship. Platforms, called decks, are laid on the beams, on which the cabins for the accommodation of officers and ship's company are placed.

The beams are so disposed on the different decks that their sides may form the hatchways and ladderways, which are the communications from one deck to another, and to the hold; and to give support to pieces fixed to them, called mast partners, for wedging and securing the masts. The beams on the different decks are placed immediately over one another, in order that pillars may be placed between them, to continue to the upper decks the support given to lower beams by pillars resting on keelson.

The deck beams are secured to the side by large timbers, called shelf-pieces, on which the beams lie, and to other large timbers called waterways, lying on ends of the beams, both well fastened to the ship's side. Knees under the beams, and steel plates bolted to the side, give additional security.

Below the lower deck, in two-decked ships and upwards, upon the inside planking, were formerly placed interior frames, in the full part of the body, extending from the keelson upwards to lower deck beams, called bends or riders; the lowest timber, called the floor rider, extended equally on each side of the middle; the other timbers, according to their position with this, were called, first, second, and third futtock riders. These timbers were intended to support the body against the upward pressure should the ship ground.

These riders are in some cases omitted, diagonal frames being introduced on the inside of frame timbers, forming a system of braces and trusses, that takes their place. The diagonal framing was brought into use to prevent ships hogging through the unequal vertical pressures of the weights downwards, and of water upwards, in different parts of a ship's length.

At the present time, a greatly improved method of diagonal framing is used. This method calls for the use of flat steel straps on the *outside* of frames, the straps being let in flush and placed to cross the frames and each other at an inclination of about 45° from the perpendicular. In addition to this, steel plate riders and a

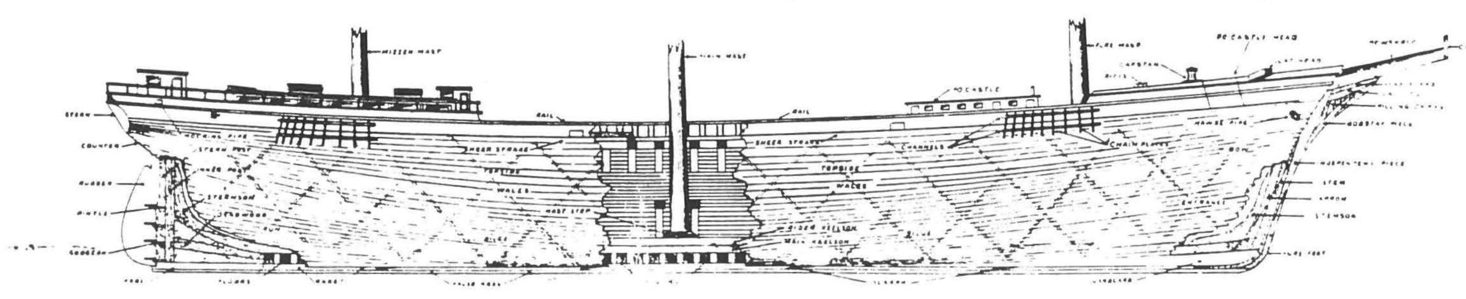


Fig. 25

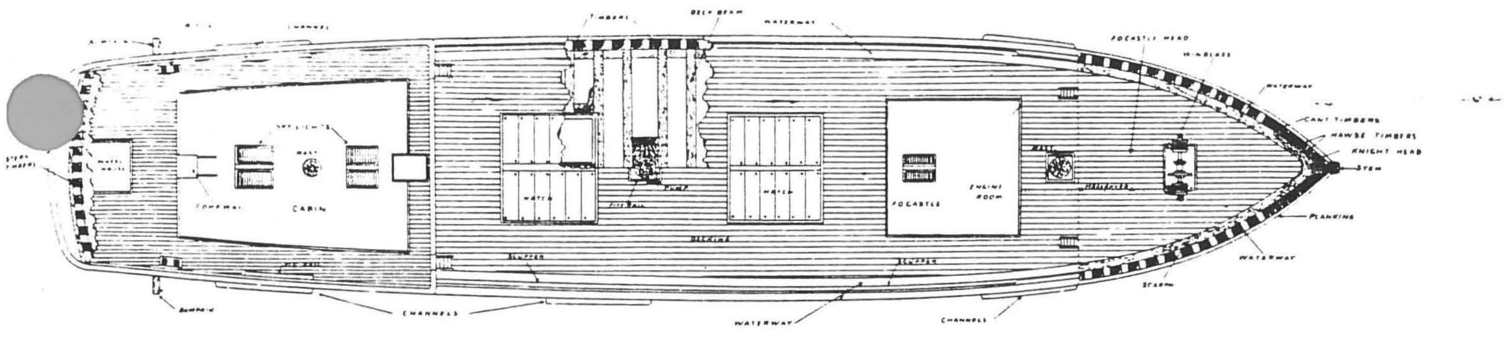


Fig. 26

steel arch are worked on inside of frames, the arch extending from near deadwood forward up to main deck beams amidships and to stern-post near deadwood aft. This arch is securely fastened to all the frames it crosses.

Figs. 25, 26, 27 and 28 show construction details of a wooden ship, the principal parts being marked for identification.

8b. Keel. Description

The keel is the principal longitudinal timber of a ship and is the first construction timber to set on the building slip blocks. A ship's keel is usually parallel sided except for a short distance near the forward and after ends, where the sided dimension is reduced to that of stem and stern post.

The sided and moulded (S. & M.) dimensions of keel required for a ship can be ascertained, when ship's tonnage is known, by referring to Table of Dimensions issued by classification society under whose rules the ship is being built, (see Tables 3b to 3f) or it can be calculated, when dimensions of ship are known, by using formula at end of Chapter III.

8b[1]. *Material For Keels*

The keel of a ship should be made of selected straight-grained, well-seasoned timber of a kind that is durable when immersed in water, and that has sufficient tensile strength to withstand the maximum keel strain.

The relative durability and strength of different kinds of woods used for keels is given in Tables 2 and 3.

In U. S. A. at present time, Douglas fir, and long-leaf yellow pine, are the two most readily procurable woods suitable for keels of large ships. Timbers of these trees can be obtained in long lengths and of better quality than other more highly rated (by insurance companies) woods, and in addition to this these woods do not shrink

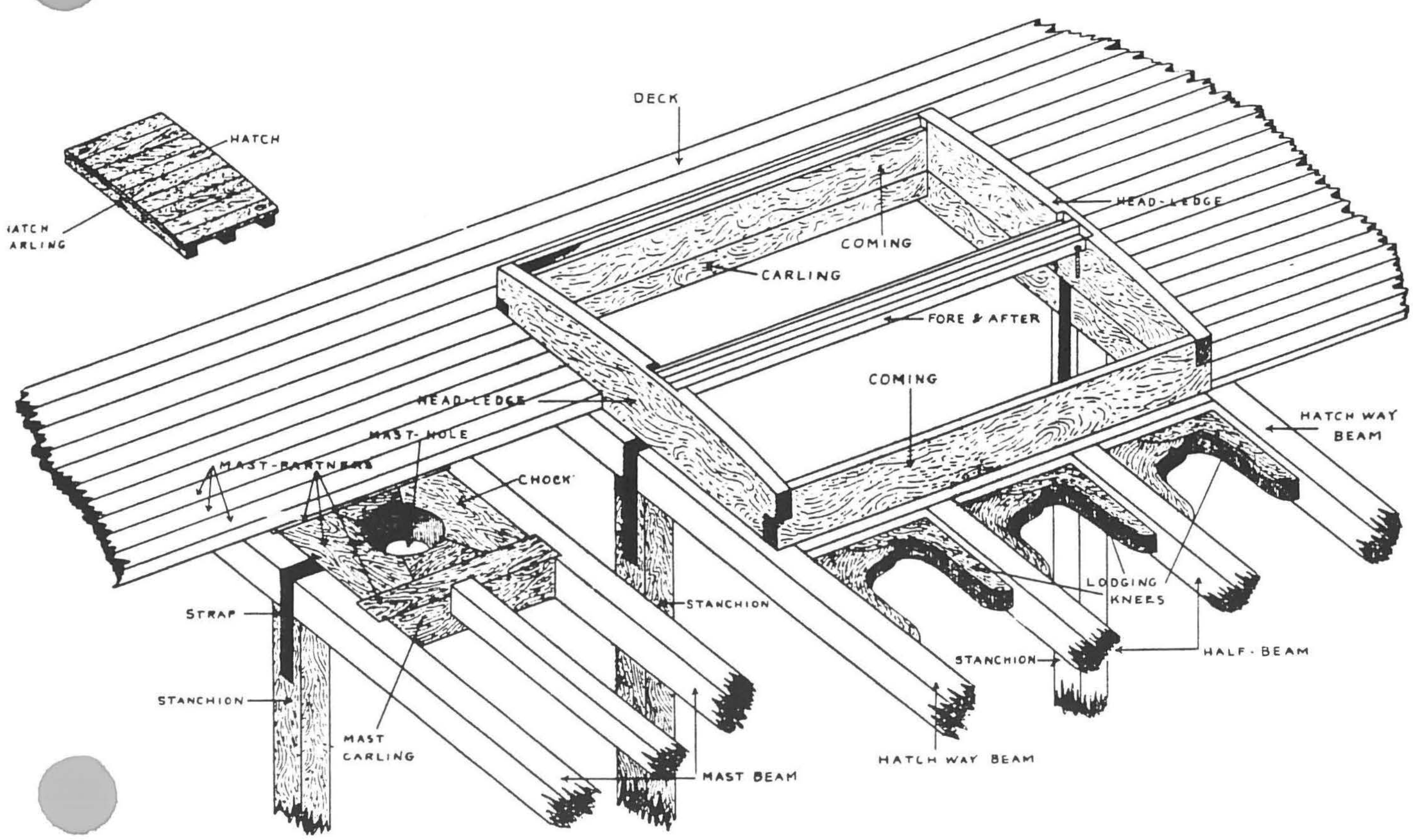


Fig. 27

very much while seasoning and for this reason, if partially seasoned timber is used, the danger of seams of scarphs opening through wood shrinking is greatly reduced.

Fig. 29 is a photograph of a ship's keel being set on building blocks; Fig. 30 shows photograph of keel, stem and stern post of a shallow draught hull set on building blocks, and Fig. 31 shows drawings of construction details of which keel forms a part.

8b². *Scarphing Keels*

As timber long enough to make a keel of a ship is difficult to obtain, it is very often necessary to join two or more pieces lengthways by scarphing and bolting or riveting. Keel scarphs should always be either nibbed or hooked, because a plain scarph lacks strength and cannot be held in place under the strain a keel is subjected to. On Plate VIIc, 6, 7, 8, I show details of plain, nibbed and hooked scarphs, the relative strength of each being: The nibbed scarph has one and one-quarter times the strength of the plain one, and the hooked scarph has two and one-half times the strength of the plain one. While scarphs can be cut either vertically or horizontally, meaning by this cut on a vertical plane parallel to moulded surface (side) of keel, or cut on a horizontal plane parallel with sided surface (top) of keel, horizontal scarphs are generally used when scarphing keels because they are easier to cut, fasten and keep tight; but no matter which kind of scarph is used, it is very important to make it of sufficient length to permit the proper number of fastenings to be driven. Length of scarphs should vary with dimensions of material and size of ship, but it is safe to adhere to this rule: *Make keel scarph extend under at least four frames* (three frame spaces).

In some cases, especially if ship is a large one, it is necessary in addition to scarphing two or more timbers

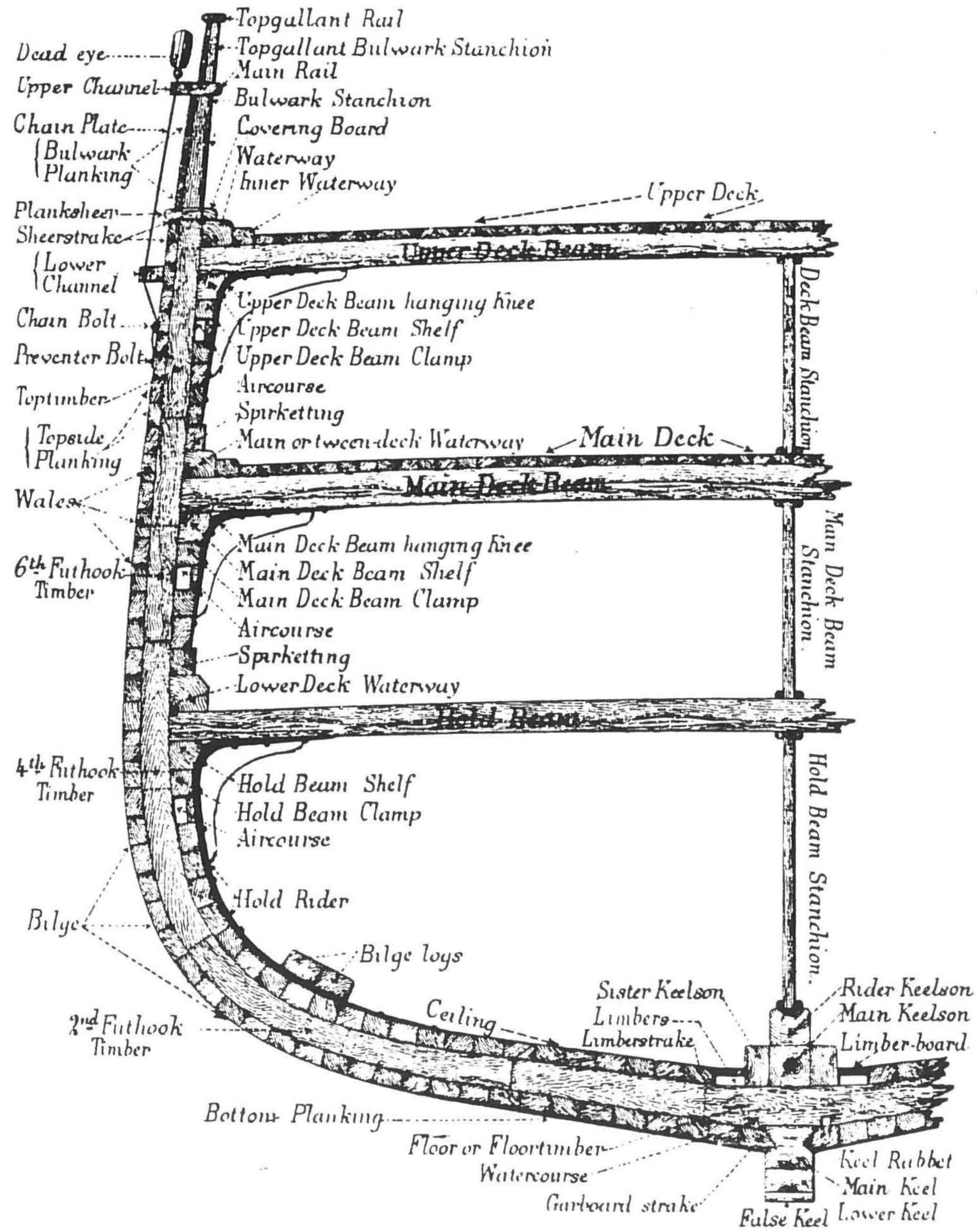
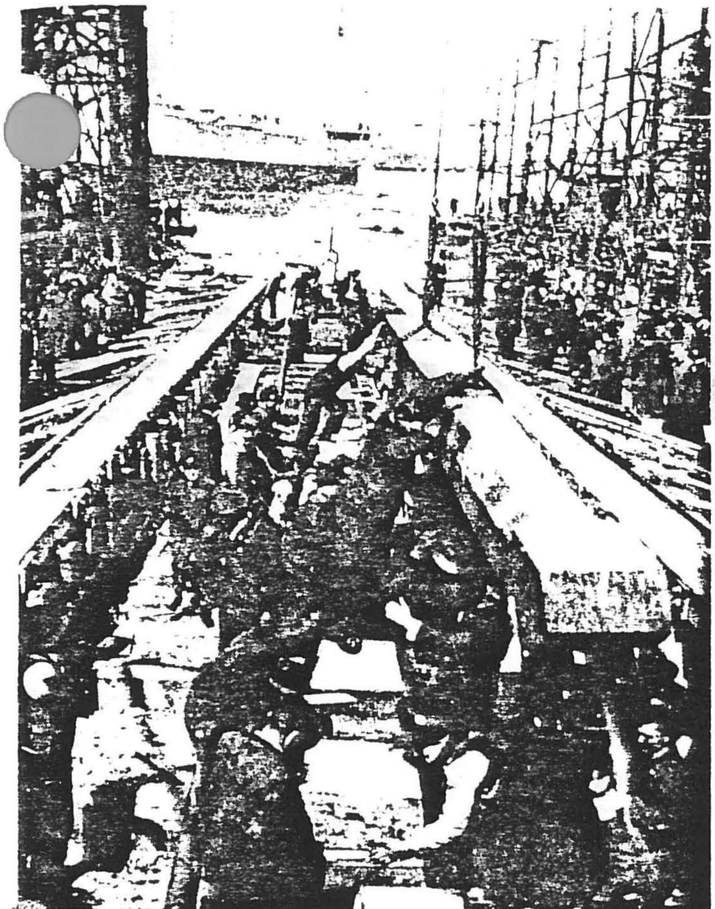


Fig. 28. Cross-Section of Ship, Showing Construction Details, Marked For Identification



Laying the Keel of Another Ship as Soon as the Accoma Left the Ways at the Foundation Company's Yard

together to make the required length of keel, to also fasten two or more timbers on top of each other to get the required moulded (depth) size.

In such cases the scarphs must be located longitudinally, so that there is a considerable distance between the location of a scarph on top keel timber and that of scarph on piece of timber immediately below. By doing this each scarph is supported and strengthened against hogging and sagging strains by the solid timber immediately below or above.

$8b^{3}$. *An Explanation of Coaked Keel Scarphs*

The word "coaked" refers to a method of increasing strength of scarphs by preventing the joint from moving sideways or endways. A coak is a rectangular or round piece of hard wood laid into the surface of two pieces of timber, that are scarphed together, in such a manner that one-half the depth of coak is in each piece of timber. On Fig. 33 is shown a properly coaked keel scarph and it is apparent that, by the addition of coaks, the resistance to sliding and holding strength of bolts has been greatly increased. In the days when wooden ships were built in large numbers, all principal keel, stem, stern, keelson and frame scarphs were coaked, but in these days coaking is seldom used, and in ignoring the advantages of coaking a scarph I believe the shipbuilders are making a serious error. With modern machinery now available every scarph could be coaked without seriously increasing cost.

$8b^{4}$. *Fastening Scarphs of Keels*

Next in importance to cutting and fitting is method of securing, because the strength and number of fastenings must be proper to withstand all strains put upon joint or scarph. Fig. 33, drawing of keel, shows two pieces of timber scarphed and fastened, the scarph being a longitudinal nibbed and coaked one. Fastenings are clearly indicated on drawing. Note there is a clench ring under the head and also under riveted end of each fastening, and that one-half the fastenings are driven from each side (top and bottom) of keel. Below I mention a few good rules to adhere to when laying out keel scarph fastenings.

(*a*) Make the diameter of fastenings in accordance with size laid down by classification society, and bore holes for fastenings with an auger that is at least one-eighth inch smaller than bolt.

(*b*) At extreme ends of scarph let there be double fastenings.

(*c*) Space intermediate fastenings equally and locate each fastening a sufficient distance inside edge of keel to bring both the fastenings and washers well inside and clear of rabbet.

(*d*) Locate all keel scarphs fastenings in positions that will not interfere with the driving of frame to keel fastenings, and keelson to frame and keel fastenings.

On Fig. 33 is shown frames and keelson in position and fastened to keel.

$8b^{5}$. *Stopwaters in Keel Scarphs*

I will next call attention to the method of keeping water from leaking through a horizontal keel scarph. Before the scarph is put together for fastening, it is usual to either paint or treat the surfaces that go together with some wood preservative and, of course, the scarph is accurately fitted before it is fastened. But these precautions do not prevent the wood shrinking and the joint opening. So it is necessary to use some methods of preventing water from passing inside the ship should a scarph joint open. The most satisfactory method of doing this is to put one or more stopwaters through the seam of a scarph in such a location that the stopwater will prevent water that passes along scarph getting inside the ship.

A stopwater is a well-seasoned soft-wood dowel or plug that is driven into a slightly smaller hole bored edgeways along the seam of a scarph in such a manner that one-half of hole will be each side of joint.

Of course the stopwater must be located in the proper position, which is, in a keel scarph like the one I am

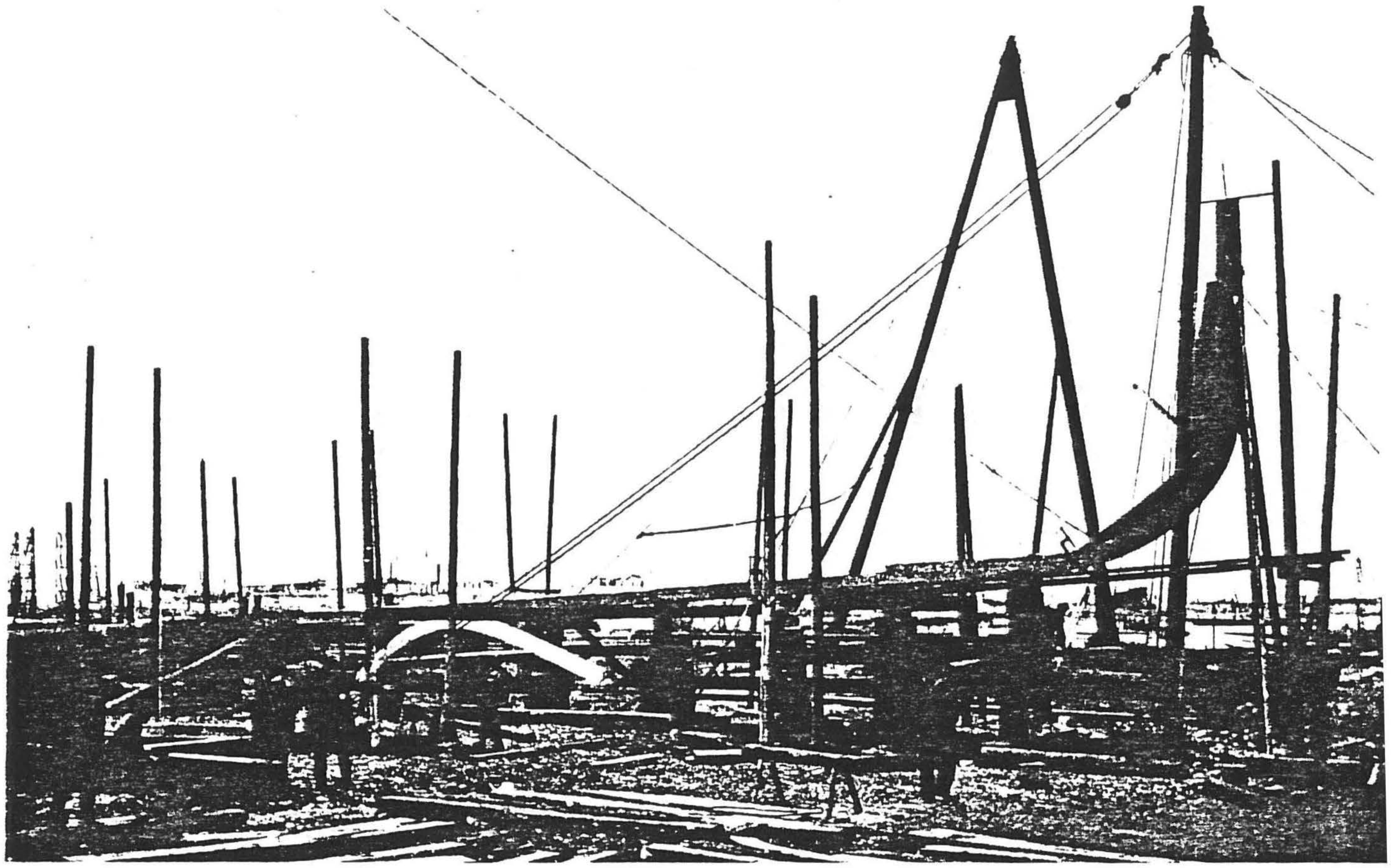


Fig. 30. Keel Set Up

referring to, in rabbet of keel. When located in this position the caulking of garboard covers end of stopwater and prevents water from passing back of it. Holes for keel stopwaters should never be bored or stopwater driven until ship is ready for planking.

On Fig. 34 I have shown keel stopwater in place; note it is in such a position that garboard will cover it.

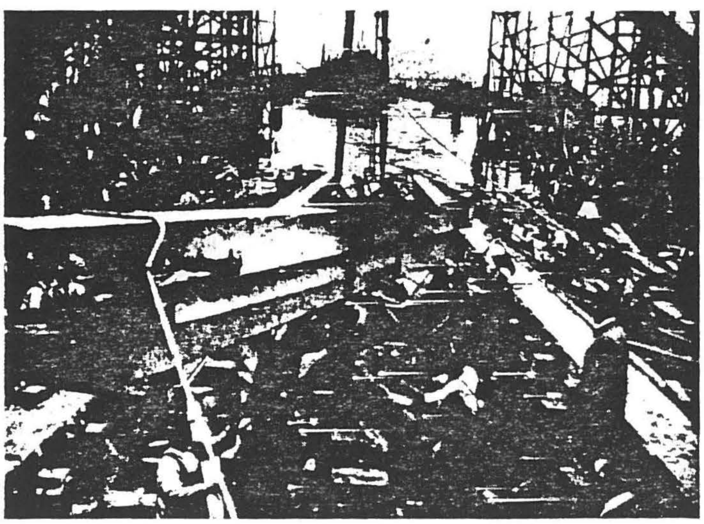


Fig. 31. As Soon as the Congaree Was Launched From the Foundation Company's Yard Workmen Laid the Keel For Another Vessel

8b[6] *Keel Rabbet*

In paragraph above I mentioned rabbet of keel, so perhaps I had better explain how a keel rabbet is cut.

The rabbet extends from end to end of keel and merges into rabbet of stem and stern; it is sometimes a groove cut at proper angle and width for plank to fit into and sometimes is formed by beveling the upper corners of keel in such a manner that garboard will fit square against keel. On cross-section construction view (Fig. 28) a grooved rabbet cut near to top of keel is shown, and on Fig. 29 (photo of keel) the beveled upper corner rabbet can clearly be seen. Note that rabbet at ends of keel is never cut until after stem and stern post is set up and fastened in place. As regards value the advantage lies with grooved rabbet, because the wood back of groove forms a backing for caulking, while the groove tends to add support to garboard along its lower edge, and in addition to this the small amount of keel wood above rabbet is sufficient to necessitate the notching of floor timbers over keel and thus they are strengthened against side thrust. As regards labor to construct the advantage lies with the beveled-edge rabbet.

8b[7]. *Edge-Bolting a Keel*

In the days when wood was the principal shipbuilding material, keels were nearly always edge-bolted, the bolts being driven from alternate side of keel and spaced

the distance alternate frames were apart, all bolts being placed some distance below garboard, as edge-bolts through garboard into keel were considered sufficient to strengthen the upper edge of keel.

Without doubt edge-bolting a keel is advantageous because it tends to prevent keel being split by driving the large number of vertical bolts that pass through it, and by the working of these bolts when ship is afloat; and in addition to this edge-bolting will oftentimes prevent a keel splitting should the ship go aground.

8b[s]. *False Keel, or Shoe*

This is a relatively thin piece of timber 2 inches to 4 inches in thickness, that is fastened below keel for the purpose of protecting its lower portion from damage should a ship go aground. On Figs. 25 and 28 the false keel is plainly marked.

The false keel extends the whole length of keel and is fastened with independent fastenings that do not pass entirely through keel, their number and strength being sufficient to secure the keel under normal conditions, but not sufficient to hold it in place should ship go aground. The false keel is always fastened in place after ship is built, and when keel timber is relatively soft material, such as Douglas fir, or long-leaf yellow pine, false keel is made of some durable wood, oak, hard maple or beech.

8c. The Stem

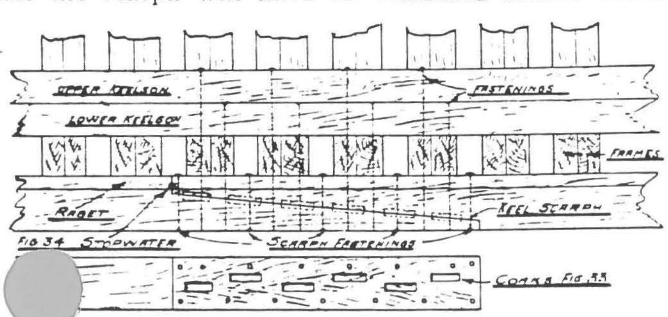
The stem is the extreme forward construction timber of hull and is the timber to which the ends of planking are fastened. The stem is attached to forward end of keel by scarphing and is reinforced and held in place by knees or timbers riveted or bolted to both keel and stem; these timbers are clearly shown on Fig. 35, which is a reproduction of the drawing of keel, stem and stemknee construction of a modern wood ship.

The Fig. 35 construction details are the simplest that it is possible to design, and in simplifying the construction strength has not been sacrificed.

For the purpose of enabling a comparison to be made between the older and more modern methods of constructing a stem I have shown on Fig. 36 stem construction of a wood ship built in 1876.

Compare Fig. 35 with Fig. 36 and the more complicated construction is noticeable.

When scarphing a stem to keel it must be remembered that the scarph will have to withstand strains coming from ahead, and therefore the scarph must be nibbed, or hooked, in such a manner that it will add strength to fastenings should the stem receive a direct blow from ahead, as would be the case should ship hit another vessel or take the ground head on.



Coaked Keel Scarph and Stopwater

On Fig. 35 and 36 the scarph fastenings are clearly shown.

You should also note that on Fig. 36 stem construction names of principal pieces are marked.

One thing should be kept in mind when laying out a stem, and that is, to have the grain of wood run lengthways of all pieces of timber. It is, of course, impossible to have full-length grain in all pieces, but if the shape of stem is such that a great deal of cross-grained wood must be used, if stem is gotten out of straight planks or timbers it is better to make use of some knees or material that has a certain amount of natural bend of grain or fibres.

Every piece of short grain should be supported or backed by a piece having straight grain and the fastenings should be spaced and located in such a manner that the several pieces of timber will be rigidly fastened together and to keel.

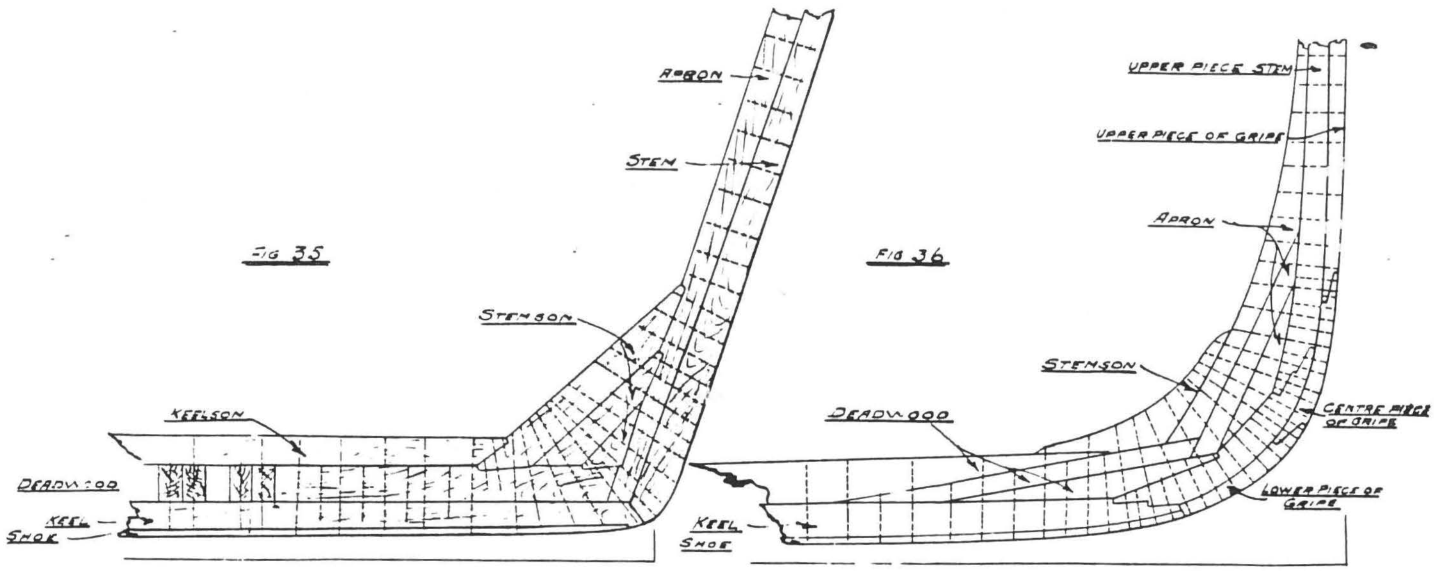
A stem receives the ends of outside planking and therefore it must have a rabbet. This rabbet is cut either upon the after edge, or along the stem a little distance inside of its after edge, but in either case the rabbet extends from stem head to keel and is backed up by apron piece into which a number of the plank end fastenings will be driven.

Ahead of rabbet the stem is beveled to take the approximate shape of longitudinal lines of ship, and after this beveling is completed the front of stem is frequently protected by a piece of steel, called a stem band, that extends from above the heavy load water-line down to forefoot.

8d. The Apron

The apron is the piece of timber that is fitted to after side of stem and extends from stem head down to forward deadwood. In fact, the apron can be considered as a continuation of forward deadwood. The apron forms a support for stem and for the fastenings that hold the forward ends of planking in place in stem rabbet. On Figs. 35 and 36, the apron is clearly indicated, as well as method of fastening it to stem. Some shipbuilders make it a practice to allow apron piece to extend to forward ends of planking, and thus the whole of rabbet is cut in apron, and stem only forms a protection for the ends of planking. This method is largely resorted to when constructing smaller craft and it has the advantage of allowing replacing a stem, should it be damaged, with the minimum of labor. This method, however, has the disadvantage of reducing strength of construction.

In large vessels the rabbet for plank is cut in stem and therefore joint between stem and apron is along a line cut a short distance inside of bearding line of rabbet.



It is usual to make apron the same width as stem, but if it is impossible to get proper bearing for planking end fastenings without increasing width of apron, the apron is made of material considerably wider than stem. In fastening apron to stem, through bolts are usually employed, and care should be taken to space them in such a manner that they will not interfere with bolts of cant timbers or breasthook fastenings. In a number of cases I have noticed that shipyards are driving apron and stem fastenings parallel to each other. This is not good practice, and much better results, so far as resistance to pulling apart or damage is concerned, will be obtained by driving fastenings at varying angles to each other. Tests of the holding power of fastenings driven parallel to each other and fastenings driven at various angles show that "various angle" fastenings have a holding power 60% greater than parallel fastenings. This test was made with 1-inch diameter fastenings connecting together two 12-inch pieces of yellow pine. The power used was applied for the purpose of separating the joint.

Hard wood is the best material to use for stem and apron, and even if stem is made of a resinous wood, such as fir or yellow pine, the apron should be of oak, or a hard wood of similar strength and durability. Apron is shown on Figs. 25, 35 and 36 illustrations.

8e. The Knightheads

Knightheads are timbers placed on each side of apron when the rabbet is on after edge of stem, and partly on stem and partly on apron when rabbet is cut along stem and apron. These timbers give support to bowsprit, and add strength to the foremost extremities of outside planking (called hooding ends.)

Knightheads should extend a sufficient height above bowsprit to receive the fastenings of bowsprit chock, and a sufficient distance below deck to give necessary added strength to the structure around the bowsprit.

When the diameter of bowsprit exceeds siding of stem at head, so that knightheads would have to be cut considerably to allow bowsprit to pass between them, pieces of timber, called stem pieces, sufficiently thick to give necessary increase of width to stem and apron, are fastened to sides of stem and apron.

Knightheads and stem pieces are made to conform to scantling of frame, and are bolted to stem. When the bow of vessel is not too acute the bolts should pass through both knightheads and stem; but when too acute the bolts can be driven from each side through one knighthead and stem only.

On Fig. 26 the knightheads are indicated.

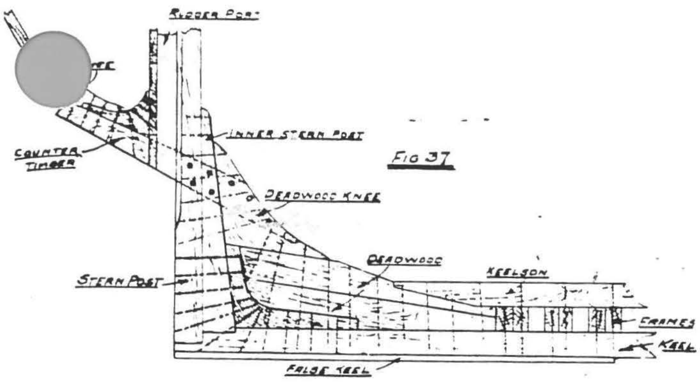
8f. Forward Deadwood

This is the piece of timber placed on top of keel, immediately aft of stem, for the purpose of making depth of wood at forward end of keel sufficient to allow a solid backing for the frames.

In most vessels, as stem is approached the lines narrow to such an extent that the frames assume a "V"-like appearance and this, of course, will increase the distance between rabbet and bearding line, and from bearding to cutting down line, or line where top edge of timbers leave side of keel, stem or deadwood. On Figs. 25, 35 and 36 the forward deadwood is clearly shown.

Fig. 35 shows modern method of forward deadwood construction when straight material is used, and Fig. 36 shows method of construction that was in use before the advent of steel ships. The old method is more complicated but it has the advantage of being more durable and stronger than the more modern method.

In constructing forward deadwood it is essential that fastenings be properly driven and correct in size and



Stern-Post, Sailing Vessel

number. It is advantageous and advisable to nib the ends of deadwood into keel and stem, and to use coaks when deadwood is built of straight material.

The size of dimensions of deadwood is usually the same as keel.

8g. Stern-Post

Stern-post is the perpendicular piece of timber fastened to after end of keel. The stern-post forms a portion of the after boundary of the framework of ship and is the timber to which after ends of all lower planks fasten.

The stern-post is usually constructed of material of sided dimensions as keel and is rabbeted to receive the ends (after hoods) of all planks that terminate at stern-post. It is usual to secure stern-post to keel by tenoning it into mortises cut into keel, and securing the tenoned lower end against rupture by placing dovetail plates (let in flush) on each side and securing them with through bolts. In addition to this the stern-post is supported and fastened to the after deadwood and to shaft log if there is one.

In vessel propelled by sail only the after end of stern-post is grooved in such a manner that forward edge of rudder post will lay close against it, and by closing the opening between stern-post and rudder eddies at this point are eliminated. In such vessels the stern-post must have a sufficient width and strength to receive the fastenings of rudder gudgeon and pintle straps.

On Fig. 37 is shown details of sternpost construction of sailing vessel, and you will note that the stern-post is composed of two pieces of material fastened together. This is done when width of available material is not sufficient, or when additional strength of stern-post is needed. The forward piece of the two is named the inner stern-post.

On Fig. 39 is shown the modern method of construction of after end of keel.

In vessels that have a screw propeller located along center line the stern-post is shaped to receive the outboard bearing of propeller shaft, and rudder is hung some distance aft of stern-post on a frame erected to receive

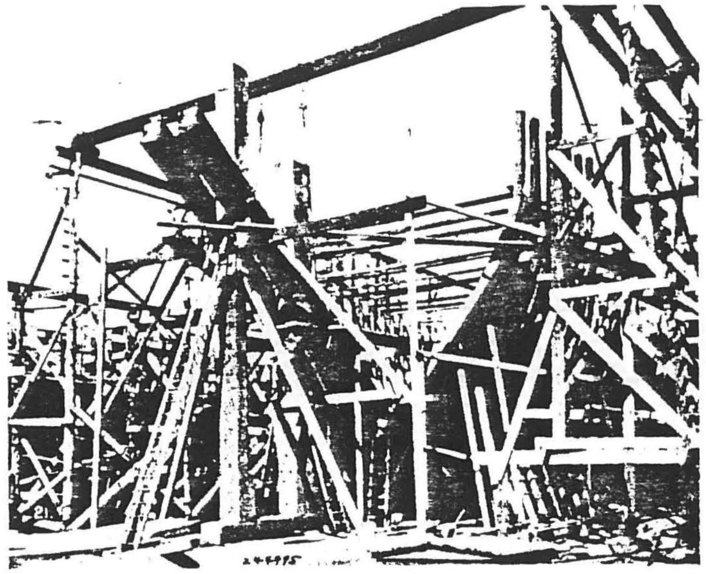


Fig. 38. Side Counter Timbers

it. Of course a hole for propeller shaft to pass through must be bored through stern-post.

On Fig. 38 I show construction of stern-post of a screw-propelled vessel.

8h. After Deadwood

The after deadwood bears the same relation to stern-post that forward deadwood does to stem. It is fitted on top of keel and against stern-post, and is sufficiently deep to permit the heels of after frames to be secured to it. The after deadwood is generally made of timber having the same siding as keel and stern-post.

In screw-propelled vessels the upper edge of deadwood timbers forms a bearing for shaft log or box, and after shaft log is in place the sternson knee is fastened in place and adds strength to the whole assemblage of pieces.

It is advantageous to use coaks in deadwood timbers and to drive the fastenings at varying angles.

On Fig. 39 construction of screw-propelled vessel's after deadwood is shown, and Fig. 37 shows construction of a sailing vessel's after deadwood; compare the two types of construction.

On Fig. 36 is shown after deadwood construction of vessel built in 1868.

8i. Counter Timbers—On Counter and Elliptical Sterns

Counter timbers extend aft from stern-post in all round and elliptical stern vessels to form the rake of stern. There are in reality three counter timbers, two *side* counter timbers and one *center* counter timber.

The side counter timbers are placed each side of stern-post, extend aft at rake that lower portion of counter must have, are set into grooves cut each side of stern-post, and securely bolted to stern-post, to deadwood, to

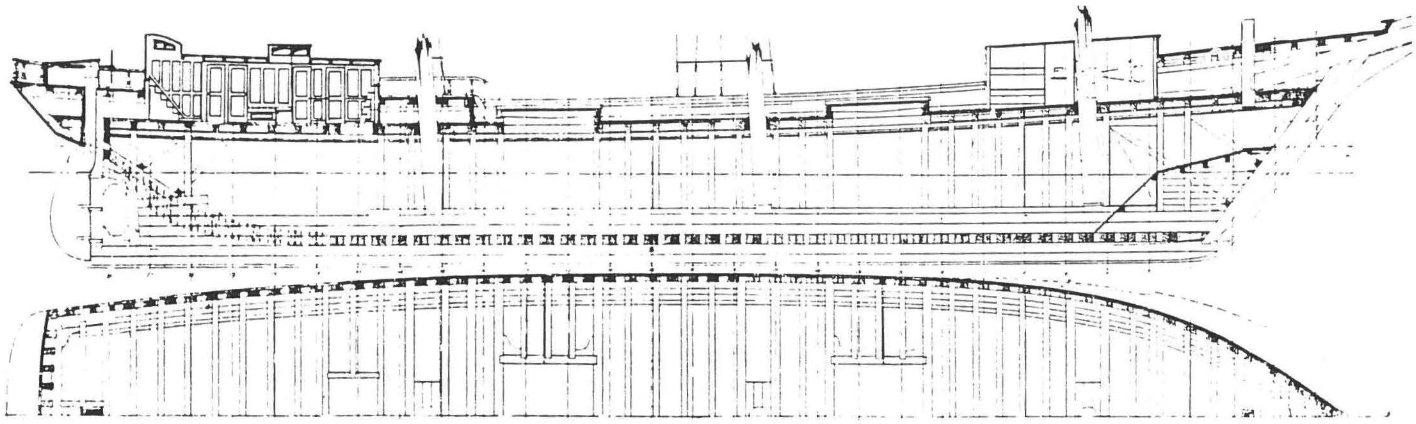


Fig. 39. Construction Plan of Three-Masted Auxiliary Schooner, Which Will Carry 700 Tons Dead Weight

each other, and to deadwood, sternson knee and shaft log (if there is a shaft log) ahead of stern-post.

On Fig. 38 the side counter timbers of an elliptical stern vessel are shown in place, and on Fig. 37 the method of fastening them to deadwood and stern-post is shown.

The center counter timber must be large enough to fill the space between side counter timbers, and as rudder-post opening is cut through the center counter timber the distance from inside of one counter timber to inside of the other one must be at least equal to diameter of rudder post.

A rudder port is constructed around rudder-post opening. After the three counter timbers are bolted together a rabbet to receive edge of planking that terminates along counter is cut along the lower outer edge of outside counter timbers.

Fig. 40 illustrates modern elliptical stern construction details.

8k. The Frame

This is the name given to the transverse timbers that are shaped to the form of vessel and placed at stated distances apart from stem to stern.

Along the center portion of a vessel, where the shape does not change very much, the frame timbers are placed square to the longitudinal plane and for this reason are named *square* frames. But at the ends (bow and stern) where shape changes considerably the frame timbers are placed obliquely to longitudinal vertical plane and for this reason are named *cant* frames. (They are canted or inclined from the perpendicular.) In addition to the frame of a vessel being composed of a number of timbers, placed as stated above, each separate frame is composed of several pieces assembled and fastened together, and each of these pieces (called timbers of the frame) has a distinguishing name, viz., first, second, third, fourth, fifth and sixth futtocks; and long and short top timbers. Of course you will understand that the number of futtocks will vary with size of vessel.

In addition to this each frame of the square body is fastened to a floor timber that scores over and lays across the keel. The cant frames do not generally have floor timbers but have their lower ends mortised directly into the deadwood or other piece of material against which they rest.

The sided and moulded dimensions of frames and also distance center of one frame is from center of next one, called timber and space, is specified for all sizes of

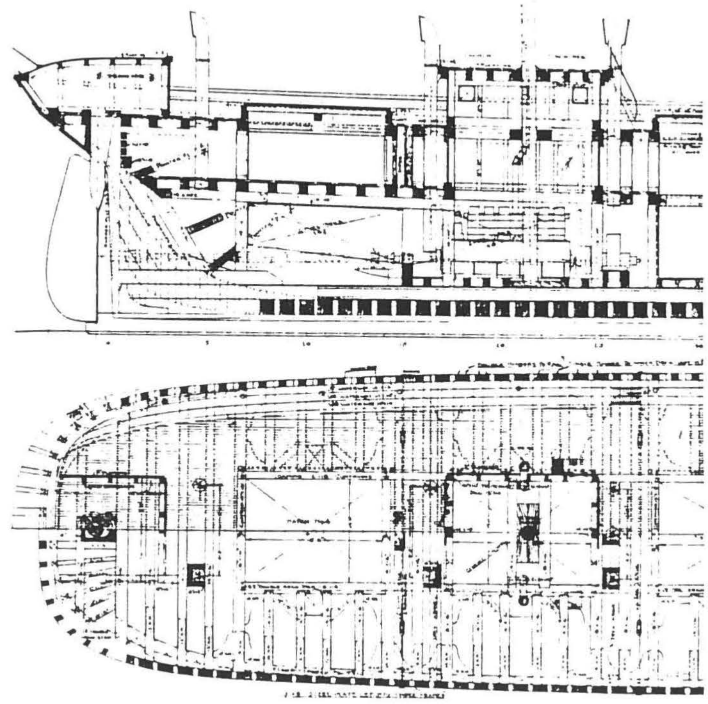


Fig. 40

vessels (see Table 3b), and Fig. 41 defines the meaning of terms Sided, Moulded, and Timber and *Space*.

Explanation of Terms

The *sided* measure of a frame is width or thickness of material of which it is composed measured on fore-and-aft line when frame is in position in vessel.

Moulded measure of a frame is width or breadth of material of which frame is composed measured along a transverse line when frame is in position in a vessel. The

term means the measurement of side on which the mould of shape of frame is placed.

Timber and space means the longitudinal space, or room, occupied by the timber of one frame added to the space between it and the next frame.

On Fig. 28 I show a transverse view of an assembled square frame, each piece of which is identified.

Beginning at the lower (keel) end of a frame I will describe each piece and explain how the various pieces are shaped and fastened together.

$8k^1$. *The Floor or Floor Timber*

This is the name of the piece of timber that crosses keel and serves to tie a frame on one side of keel with one on the other. On the illustration the floor is clearly marked.

The floors of the midship frame usually, in flat-floored ships, extend out to about one-fourth the breadth on each

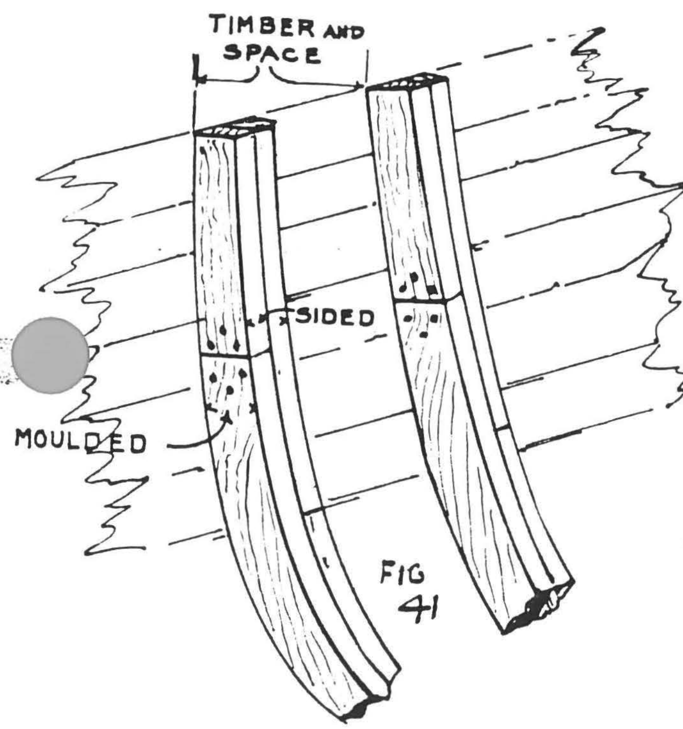


FIG 41

side of keel, but it must be remembered that if the floors are *doubled* (two floors placed alongside of each other) each will have a long and a short arm, the long arm of one floor being on side of keel that the short arm of adjacent one is. The reason for this is explained in description of frame timbers.

Floors are secured to keel with bolts, and if notched over keel their lowest points must exactly reach to bearding line of rabbet. The distance from bearding line of rabbet of keel to the upper part of floors, at their center line, is called the cutting down, or throating.

Dimensions of floors and their fastenings are given in Tables 3b and 3d.

$8k^2$. *The Frame Timbers*

The pieces of timber of which a frame is composed must be disposed in such a manner that they can be fastened together securely. This is done by shifting the butts and bolting the pieces together in the manner illustrated on Figs. 28 and 42a and explained below.

The floor on illustration is a double one, the dash line marked near keel across it indicating the end of a short arm, and the full line a little further out indicating end of a long arm.

The first futtock is butted against the end of short arm of floor and the upper end of this futtock extends to dotted line next above the full line that indicates end of long arm of floor. This permits lower portion of first futtock to be bolted to portion of long-arm floor that extends beyond the short arm of adjacent floor. The lower end of second futtock butts against long-arm end of floor and upper end of this futtock extends some distance above upper end of first futtock. The lower end of second futtock is fastened to portion of upper end of first futtock that extends beyond end of long arm of floor. In this manner each succeeding futtock overlaps and is bolted to the one below, and thus any short grain of wood at the end of a futtock is strengthened by the long grain of piece that overlaps it. On illustration the even numbered futtocks are marked for identification, and location of odd numbered ones is indicated by dash lines and numbers only.

Bolts are used to fasten the futtocks to floor arms and to each other, and if maximum strength is desired round coaks are inserted between the overlapping portions of futtocks.

All fastenings of futtocks should be located in positions that will keep them clear of knee and waterway fastenings, and if filling frames are to be used the heads and ends of bolts that are located where filling frames will be must be countersunk flush with surface of wood.

$8k^3$. *Filling Frames*

This is the name given to short frames located between the frames proper and extending from keel to about the turn of bilge. Their use is to strengthen the transverse bottom framing of vessel, but originally they were used in conjunction with caulking to make the whole of bottom of a vessel's transverse framing watertight.

The old method of using filling frames was to make these frames extend from keel to orlop deck location and to completely fill spaces between frames proper. Thus the whole of bottom and bilges of a vessel was made one solid mass of wood, and when the seams between the various frames and filling frames were caulked with oakum the whole bottom framing of vessel was made watertight. Construction of this kind requires a very large amount of material, and the weight of a vessel constructed in this manner is much greater than that of a vessel constructed in accordance with modern ideas of what is proper and necessary. In present-day construction of large vessels one filling frame, or at most two,

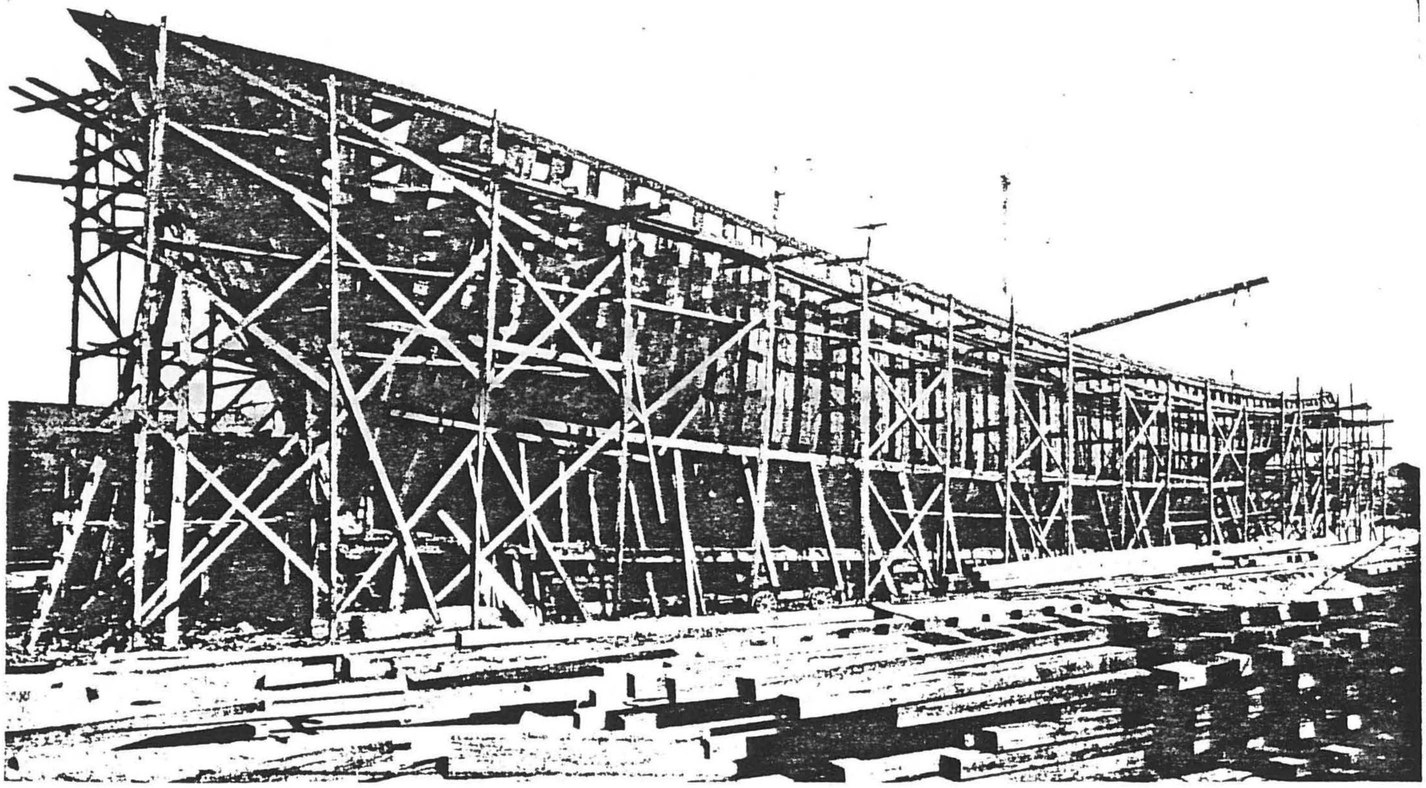


Fig. 42. The Dimensions Are: L. O. A. 200 Ft., Length on Deck 177 Ft., Breadth 36 Ft. 8 In. She Is to be Rigged With Four Masts

is placed between each two regular frames, the filling frames extending out to about turn of bilge.

In small and moderate sized vessels the filling frames are frequently omitted entirely.

In addition to these filling frames, filling pieces are placed in the wake of fore, main, and mizzen rigging, wherever a valve connection passes through the bottom or side of vessel, where a knee will not coincide with a regular frame, and wherever an opening of any kind is cut through side or bottom.

8k[4]. *Cant Frames*

I have already mentioned that some of the frames are canted out of perpendicular. I will now explain the reason for doing this.

When referring to the transverse framing a vessel is considered as being divided into two principal parts, one part being named the square body frame and the other the cant body frame. Along the square body (the part of a vessel where the shape of cross-section changes very little) the frames stand perpendicular at right angles to center line of keel, and parallel to each other; and along the portions of a vessel where cant frames are located the frames are canted, or swung around to an angle, thus increasing the distance they are apart at deck line. Cant frames are canted forward at bow, and aft at stern, the number of cant frames varying in each vessel and depending upon fullness at deck relative to fullness along deadwood at stem and stern. The reason that forward and aft frames of a wooden vessel are canted is, that in the parts where deck outline merges into stem, and around the curve of an elliptical stern square timbers would have to be beveled to an excessive degree to make planking lay against the frames for their full width, and this excessive beveling would greatly weaken frames; or if frames were a sufficient width to allow for beveling an excessive amount of material would be wasted.

By inclining, or canting, each frame so that its outer face parallels, as near as possible, the deck outline the amount of bevel necessary to make plank fit against a frame for its full width is greatly reduced and additional strength of frame is obtained without adding to the material. Cant frames at bow always cant forward and those at stern cant aft.

On Fig. 42 I show views of forward cant frames in position. You will note by referring to illustration that no change is made in spacing of lower ends of cant frames, but by canting the actual interval (space) between upper ends of frames increases, and as outer face of frames more nearly follows shape of vessel's outline, they offer a greater resistance to pressure of waves at bow and at stern.

The lower ends of cant frames are always "boxed" into deadwood about 1½ inches deep, except in range of a shaft hole, and each cant frame is bolted through deadwood.

Before the days of steel ships it was usual to cant all frames ahead and aft of the middle body, but modern wooden shipbuilders do not consider it necessary to cant

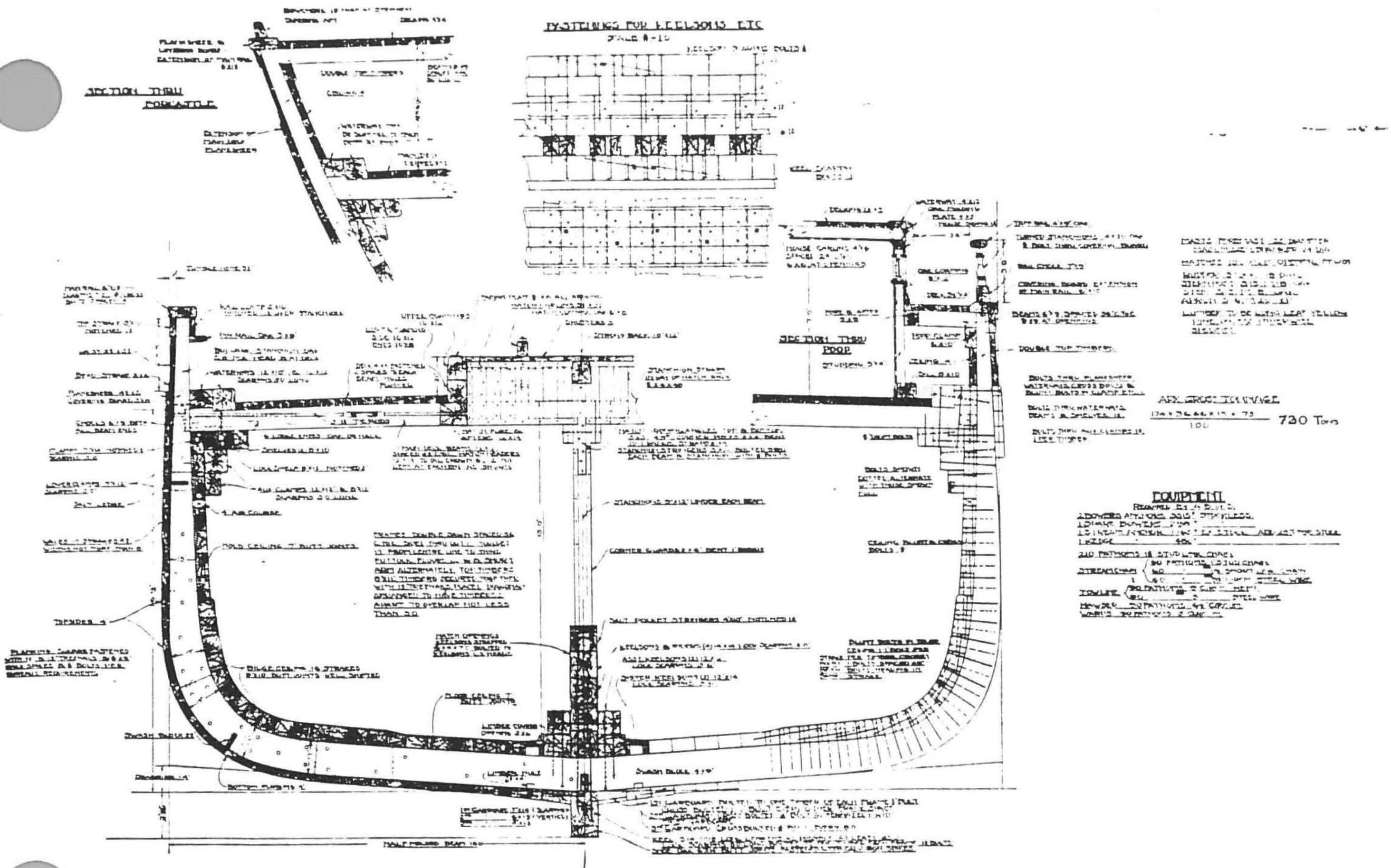


Fig. 42a. Midship Construction Plan of Four-Masted Schooner Building For J. W. Somerville, Designed by Cox & Stevens

more than a few frames at extreme bow and a few at extreme stern.

The old method is certainly the best but it entails a greater amount of work both in the mould loft and when erecting the frame.

8l. Hawse Pieces

Hawse pieces are pieces of timber used to fill in between the knightheads and the foremost cant frames. Their use is to give solid wood for the hawse pipe to pass through and fasten to.

In reality hawse pieces are cant frames that close the openings between forward cant frames from the knightheads aft as far as necessary to give good solid fastening for hawse-pipe flanges. The lower ends of hawse timbers are bolted to the apron and the several hawse timbers are edge-bolted together, care being taken to keep bolts clear of positions where breasthooks and hawse holes are located. On Figs. 25 and 26 hawse pieces are marked and on Fig. 42 they are very clearly shown.

8m. Keelsons

8m¹. *Main*

[illegible] keelson is a timber placed immediately over keel on top of the floors, over which it is sometimes notched, and extending from forward deadwood to after deadwood. It unites in one solid structure the keel, floors and deadwoods.

The main keelson is usually built up of a number of pieces scarphed together, and when laying out a keelson it is necessary to locate the scarphs in positions that will not bring them immediately over a keel scarph. The scarphs are usually nibbed and have a length equal to at least two frame intervals (double the room and space). Some of the fastenings of scarphs must pass through both floors and keel, and if the maximum strength of construction is desired two or three circular coaks should be fitted into each scarph. The lips of scarphs are fastened with two short bolts that do not pass through keel.

At forward end of vessel the main keelson usually scarphs into deadwood and is then secured to apron by means of a stemson knee. Aft the main keelson scarphs into deadwood and in some vessels the sternson knee rests upon main keelson and serves to fasten its after end to stern-post.

The main keelson is fastened in place with bolts that pass through floors and into keel, and in vessels that are well constructed additional strength is given to the whole structure by coaking the lower piece of main keelson to each floor and filling that it crosses: 3-inch diameter coaks are used for doing this.

If the main keelson is built up of two or more timbers placed on top of each other the pieces should be

coaked together with square coaks before the through floor and keel fastenings are driven.

On Figs. 25, 28, 35 a main keelson is shown in its proper position in a vessel.

8m². *Sister Keelsons*

Sister keelsons are generally placed each side of and close to main keelson, extending fore-and-aft parallel with main keelson to where the reduction in width of floor of vessel reduces their depth to about 6 inches.

These keelsons, in properly constructed vessels, are coaked to floors and filling timbers with circular coaks, then bolted to floors and fillings and edge-bolted to main keelson. Scarphs of sister keelsons are cut and fastened the same as main keelson scarphs. On Fig. 28 sister keelsons are shown in place.

8m³. *Boiler or Bilge Keelsons*

In all vessels having machinery, two or more boiler or bilge keelsons are run parallel with sister keelsons and sufficiently apart to form the lower timber of engine and boiler foundations. These keelsons are coaked and fastened to all frames and filling they cross, and are always extended as far as possible forward and aft, because by doing this the strain caused by weight of machinery, as well as the local vibrations caused by the rotation of engine crank are spread over a wide extent of the structure.

8m⁴. *Rider Keelsons*

Rider keelsons are placed on top of main keelsons for the purpose of giving additional strength to the whole longitudinal structure of a vessel. In Chapter V on Strains I explained that hogging and sagging strains can best be resisted by adding strength to the longitudinal members of a vessel's structure, and this the rider keelson does.

On Fig. 28 a rider keelson is shown in position.

Rider keelson scarphs and fastenings are similar to those in keelsons, and of course scarphs must be properly located so as not to coincide with keelson or keel scarphs.

Power of resistance against hogging and sagging strains is increased when rider keelson fastenings are diagonally driven at varying angles from the perpendicular.

8n. Stemson

The stemson is the piece of material, a natural knee, placed in angle formed by apron, upper piece of deadwood and forward end of keelson. It acts as an additional support for stem and serves to properly tie keelson and forward deadwood to stem and apron.

The fastenings go through stem, apron and stemson at one end, and keel, deadwood, keelson and stemson at the other.

It is advantageous to use coaks in addition to the metal fastenings, and of course all fastenings should be through bolts clenched on rings.

On Fig. 25 the stemson is clearly indicated.

8o. Sternson

The sternson bears the same relation to stern-post that stemson does to stem. It is used to strengthen stern-post and is, in the case of vessels having a shaft log, placed on top of log and serves to hold log in position.

On Fig. 25 a sternson knee is shown, but in present-day practice stemson and sternson knees are now seldom used, as an examination of illustrations and construction details shown in this book will indicate.

8p. Diagonal Steel Bracing of Frame

Steel straps are fastened diagonally across outside of the frame of a vessel for the purpose of strengthening vessel against strains that tend to change its shape longitudinally. (Hogging or sagging strains.) These straps are let into frames flush, cross frames at about 45° inclination, and are fastened with at least one bolt through each strap into each frame, and to each other with rivets wherever two straps cross. The dimensions of straps, their number and location varies with the size of the vessel. (See Table 3a in Chapter III.)

On Fig. 25 is shown by dotted lines the general direction of diagonal straps. In large vessels, in addition to diagonal straps, it is usual to insert a steel strap arch on inside of frames. This arch begins at stem near to deadwood, rises in a curve to lower side of upper deck beams at about midships, and from these descends in a curve to near deadwood at stern-post. This strap is let into frames flush and is fastened in place with one bolt into each frame. Bear in mind that these and the diagonal straps are supplemented later by one or more of the planking fastenings at each frame going through both strap and frame.

8q. Planking

Planking is the name given to outer covering of the transverse frame. It is put on in strakes that run from stem to stern, each strake being properly proportioned in width from bow to midship and from midship to stern. In other words, the planks are not parallel for their entire length but have their widths graduated in such a manner that the number of planks required to fill space at stem, which is the narrowest space to fill, will also fill space at midship section, which is the widest space to fil. A single plank that runs from stem to stern is called a strake of planking. Below I give names and description of principal planks.

8q¹. *Garboard*

The plank next to keel is named the garboard. The lower edge of this plank is fitted into rabbet of keel, stem, and stern-post, and it is usual to edge-bolt this plank to keel, in addition to fastening it in the usual manner to all frames at crosses. The garboard is generally made of thicker material than rest of planking, as you will note by referring to Fig. 42a.

In a large vessel there may be two or three thick strakes next to garboard proper. In such cases each strake is slightly thinner than garboard proper, and it is correct to refer to all these thick strakes as being garboard strakes. Technically there can be only one garboard strake, but as it is impossible to obtain one plank sufficiently wide to cover the space that thick strake next to keel should cover, the term garboard is used when referring to all thick strakes next to keel.

On Fig. 42a three thick strakes are shown and you will note how each succeeding plank is slightly thinner than the last one put on. When planking a vessel the garboard is the first bottom plank put in position and after vessel is planked the excess thickness is "dubbed off" for a few feet at bow and stern.

8q². *Sheer Strake*

The top strake of planking is called the sheer. This is usually the first strake of planking put on.

As this plank is an important one in the assemblage of planks that aid in resisting longitudinal strains its strength should be at a maximum, and for this reason butts of sheer strake should also be scarphed and edge-bolted instead of being butted in the manner that planks of other strakes are joined. On Fig. 43 is shown a proper method of scarphing and fastening a sheer strake.

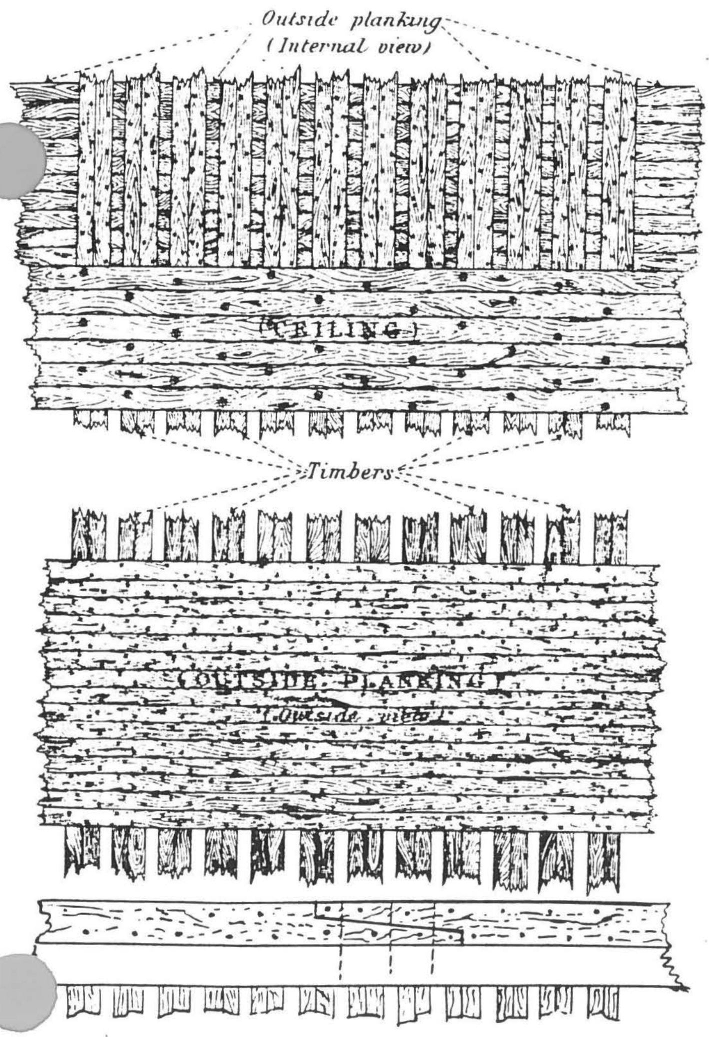


Fig. 43

The scarph, as you will note, is a nibbed one that extends across three frames and after planks are fastened in position the scarph is edge-bolted between frames, the edge-bolts passing through sheer and into next plank below.

8q³. *The Wales (an old term)*

This name applies to an assemblage of planks that covers the frame from immediately below sheer strakes (the three or four top strakes used to be termed sheer planking) to bilge planking, which commences at or near to bilge. The term is seldom used by shipbuilders of the new school.

The wales were always somewhat thicker than the rest of planking and it was usual to designate wale strakes according to their location. Thus the wale strakes located where channel fastenings are, were named *channel wales*. The planks below were named the *main wales,* and below these again were the *diminishing strakes,* so called because it was here the planks began to be diminished in thickness and merge into bottom planks located immediately below the diminishing strakes and which filled space between them and garboard strakes.

On Fig. 28 I have identified the various assemblages of planks by marking names against them.

New Planking Names

The present-day method of planking is similar to the old in many respects, but as all planks between sheer and garboard strakes are alike in thickness and method of fastening, the old distinguishing names for the thicker planks have become obsolete and now all planks between top of garboard and bilge are known as bottom planking, and that from bilge to under side of sheer as topside planking, or side planking.

On Fig. 42a illustration shows the new planking method with names of assemblage of planks marked for identification.

8q⁴. *Caulking*

Caulking is the operation of making seams of planking watertight by forcing oakum into the seams by means of a caulking iron and mallet. In caulking the thickness of plank regulates the quantity of oakum that should be driven into each seam or butt joint. The following table gives number of threads of oakum for planks from 10 inches down to 1 inch thick.

	Thickness of Plank	Number of Double Threads of Oakum	Number of Single Threads of Spunyarn	
Wales and bottom planks.	10 inches	13	2	Seldom used now
	9 "	12	2	
	8 "	11	2	
	7 "	10	2	
	6 "	8	2	
	5 "	6	2	
	4 "	5	2	
	3 "	4	1	
	2½ "	3	—	
	2 "	2	—	
	1 "	1	—	

		Double Threads, Black Oakum	Double Threads, White Oakum or Cotton
Topsides and Waterways	9 inches	11	—
	8 "	10	—
	7 "	9	—
	6 "	7	—
	5 "	5	1
	4 "	4	1
	3 "	3	1
	2½ "	2	1
		Single Threads, Black Oakum	**Single Threads, White Oakum or Cotton**
Deck.	4 inches	3	1
	3 "	2	1
	2½ inches	2	1
	2 "	1	1

In order that the proper quantity of oakum may be driven all seams to be caulked are made tight at the bottom and open at surface. This is called allowing the seam.

The necessary seam for plank of any thickness may be found by drawing two lines, 10 inches long, so that they meet at one end, and are ½ inch apart at the other; if the thickness of plank be set off from the point where lines meet, the distance lines are apart at this place will be the open seam that must be allowed. The progressive manner of caulking is, by first driving wedge-like irons into the seams to open them on the surface. This operation is called raiming or reeming. After this, the spunyarn, white oakum or cotton, is driven, if any, and then the number of black threads, which are then hardened, or what is called horsed up; this is done by one man holding, in the seam upon the oakum, an iron, fixed in a handle, called the horse iron, and another driving upon it with a large mallet, called a beetle, that the oakum may be made as firm as possible and be below the outer surface of the plank. It is of importance, in order to give firmness to the caulking, and to prevent decay, that the threads be driven into the seam as far as possible, or driven home, and not choked, as is sometimes the case. The whole of the oakum driven should form a wedge and be what is called, well bottomed.

On Fig. 44 are shown men engaged in caulking outside planking seams of a vessel's bottom.

Fig. 44

Inside Planking of a Vessel

8q⁵. *Ceiling*

This is the name given to planking that covers *inside* of the frames of a vessel. It begins below clamps and covers the entire inside of frames from clamps to keelson.

On Figs. 28, 43 and 43a methods of fastening the ceiling are clearly shown and on Fig. 42a is shown present-day method of ceiling a vessel which I will now describe.

Immediately next to keelson is laid the *limber strake,* which is a strake of ceiling placed in such a position that by removing portions of it access to limber chains or watercourses can be obtained. (See Fig. 28.)

Immediately next to limber strake begins the ceiling proper and this extends to just below turn of bilge where the bilge ceiling begins. The bilge ceiling is of thicker material than ceiling proper and extends up until curve of bilge is passed, when the thinner ceiling again begins and extends up to air course left directly under clamps.

Ceiling extends from bow to stern, is put on in strakes that fit tightly against one another, and is securely fastened to frames and filling, some of the fastenings going through both frames and outside planking. On Fig. 43b is shown interior view of a vessel with bottom ceiling in place.

8q⁶. *Fastening the Planking*

It is necessary to describe the fastenings both outside and inside (ceiling) planking at one time because many of the fastenings go through outer plank, frame, and inner plank. Correct fastening of planking is essential for strength, and not only must the fastenings be ample in number and of proper size, but they must be properly located and driven.

First I will call your attention to a most important detail of fastening frequently overlooked by shipbuilders of the present-day.

All plank fastenings are driven through holes bored with an auger. Up to within the last year or so these fastening holes were bored with hand-operated augers, and the regulations for proper sizes of holes (based upon experience) stipulated that holes should be bored ⅛ inch

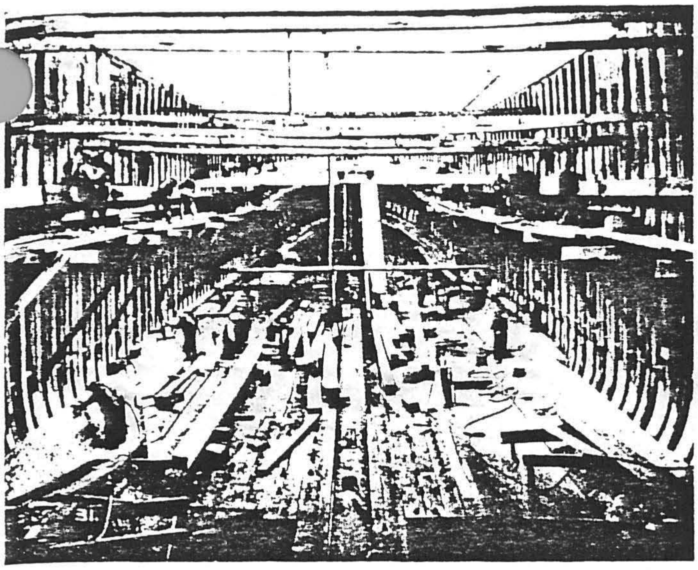


Fig 43a. Laying Ceiling

(for 1-inch fastening) *smaller* than fastening. This insured that fastening would fit tightly into hole and hold properly after it was driven. This regulation for *hand-bored* fastening holes is absolutely sound and correct, but when it is applied to *machine-drilled* holes it is *incorrect* and results in fastenings being loose and insecure.

When a fastening hole is drilled with an auger attached to an air-driven tool *the auger should be one or two sizes SMALLER than the one used for boring for same sized fastening by hand.* The smaller size auger is necessary when a machine is used because the higher speed of rotation, coupled with the difficulty of holding auger perfectly vertical and steady, nearly always causes the hole to assume an oblong shape and to become slightly larger than size of auger.

Whenever a fastening hole is to be bored with a machine-operated auger use an auger one size smaller than is specified for hand-operated augers.

Two kinds of fastenings are used for connecting planking to the frame; *wood* (called treenails) and *metal* (copper, composition metal, or iron), and the fastenings can be spaced either single, double, or alternate single and double.

By single fastening is meant each strake having one fastening of each kind into each frame; by double fastening is meant each strake having two fastenings of each kind into each frame, and by alternate fastening is meant each strake having one fastening of each kind in every other frame and two fastenings of each kind into each frame between single fastened frames.

On Fig. 45 is shown sections of planking with single, double, and alternate fastenings through each strake. Before the advent of steel ships the larger wooden vessels were nearly always double fastened, medium-sized ones were double fastened above water and alternate fastened below, and the smaller ones were alternate fastened above water and single fastened below. This practice was an excellent one and with this modification should be followed in these days: *Wherever fastenings of knees, clamps, shelf, pointers,* or *riders* pass through frame and outer planking the planking fastenings should be only sufficient in number to draw planking to its position against frames.

The reason for this modification is: The through fastenings of parts mentioned must have a clear passageway through frames and must have proper amount of solid wood surrounding them. If double fastenings of planking are driven in places where other fastenings must pass through, one of two things may happen,—either the additional fastenings will cut an excessive amount of wood from frames and thus weaken the frame, or else the fastenings of planking will interfere with knee and other additional fastenings.

It is well to bear in mind this important fact—*treenail* fastenings resist transverse strains better than metal, but the metal will better resist direct separation strains. It therefore is apparent that a wise combination of the two kinds of fastenings is most desirable.

As the inside planking (ceiling) is not laid at the same time that outside planking is a certain proportion of both outer and inner planking fastenings must be driven into frames only.

The usual manner of fastening is somewhat along these lines: The outer planking is first fastened with a certain number of metal fastenings that pass through

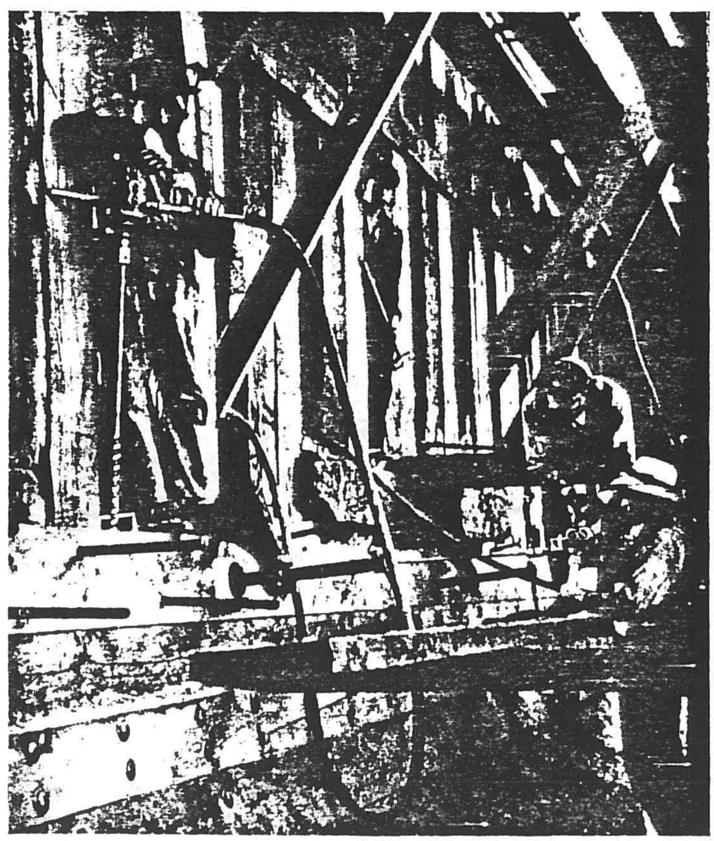


Fig. 43b. Edge Bolting Ceiling

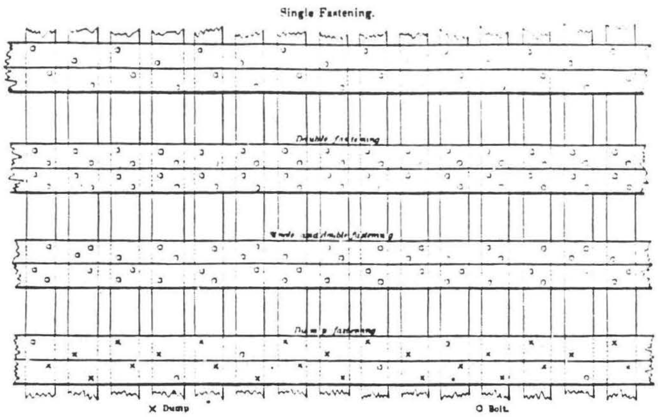


Fig. 45. Planking Fastenings

planking and into frames for about two-thirds of their depth, a certain number of treenail fastenings are then driven through outer planking and frames and wedged tight. These fastenings are only sufficient in number to securely hold planking in position until inner planking (ceiling) is wrought.

The ceiling is first fastened with a minimum number of short fastenings that only pass through ceiling and into frames. After ceiling is in place the planking fastenings that go through outer and inner planking and frame are put in, the metal ones being clenched and the wood ones wedged.

To fasten butts through bolts, treenails and short welts are used. Butts are usually cut upon the middle of a timber and are fastened with one treenail and one short bolt through the butt of each plank into butt timber (timber butt is cut on) and one through bolt, called a butt bolt, in timbers nearest to butt timber.

On Fig. 46 is shown a properly cut and fastened butt and below the illustration are given rules for spacing butts.

Now a few words about wedging treenails.

After treenails are driven their ends are cut off flush and wedged with hardwood wedges, the wedges serving the double purpose of expanding ends of treenails and thus increasing resistance to separation of the two or three pieces of material that the treenails fasten together; and of caulking the ends.

Very large treenails used to be caulked with three wedges forming a triangle, and small ones with two wedges crossing each other at right angles, but in these days the practice is to use the cross wedges on very large treenails and a single wedge on the smaller ones. Treenails *must* drive tight, meaning by this, be driven through holes that are somewhat smaller than the treenail. On Fig. 47 are shown a number of treenails ready to drive.

8r. The Clamps

The clamps are two or three thick planks extending the whole length of frame and located immediately under each tier of deck beams, their use being to help support deck beams and add strength to the structure along point of joining of a deck with side framing.

In sailing vessels the deck beams very often rest directly upon clamps and are fastened to them and to frame of vessel with hanging knees. These knees are shown in outline on Fig. 28.

In ships driven by steam and in many of the larger sailing crafts the clamps form a backing for shelf on which the deck beams rest.

Each tier of beams has its clamps and shelf. (See Fig. 28.)

The upper edge of each set of clamps is usually located at proper height to allow deck beams to be let in about one inch, or if it is not intended to let beams in, the upper edge is placed high enough for beams to have a full bearing.

If maximum strength is desired clamps should be coaked to frames, each assemblage of clamps should be edge-bolted between timbers and butts should be scarphed; the scarphs being sufficiently long to extend over and fasten to three frames. All scarphs should be properly edge-bolted.

Clamps are usually first fastened to frames only, and after they are firmly set in their proper position additional fastenings that go through outer planking, frame and clamp, are driven from outside and clenched on clamp.

8r[1]. *Air Course*

This is an opening left immediately under lowest clamp plank for the purpose of allowing air to circulate freely around the frames. (See Fig. 28.)

8s. The Shelf

This is the name given to a heavy continuous timber, or a combination of two or more timbers, that extends from bow to stern at each tier of deck beams and is fastened to inner face of upper clamps in a position that will allow deck beams to have a full width bearing on upper face of shelf.

On Fig. 42a the shelf is shown in position under a deck beam. Shelf timbers are usually scarphed in the same manner that clamps are, and are securely fastened to clamps, frames and outer planking.

The duty of a shelf is to resist strains tending to extend the vessel, to support deck beams and form a secure base for securing them to.

8s[1]. *Shelf Fastenings*

Shelves are fastened in the same manner that clamps are and, in addition, they are fastened to clamps with metal fastenings driven through shelf and into at least two of the clamp timbers. (See Fig. 42a.)

8t. Deck Beams

Deck beams are horizontal timbers that extend across a vessel and support the decking. The ends of deck

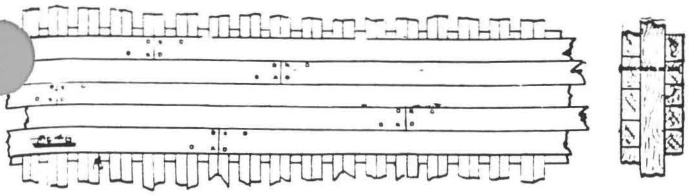


Fig. 46. Butt Fastenings

beams rest upon shelf and clamps and are strengthened by means of hanging knees (vertical knees), one end of which fastens to beams and the other to clamps, ceiling, and frames at side. In addition to these hanging knees a certain number of horizontal ones, called *lodge knees*, are fastened at designated positions throughout length of vessel. On Fig. 28 the vertical knees are shown in place, and on Fig. 27 is shown some lodge knees.

Along center line of vessel the deck beams are supported by pillars or stanchions that have their lower ends firmly resting on and secured to keelson and their upper ends secured to a longitudinal deck stringer and to the beams. Separate longitudinal stringers and stanchions are fitted between each tier of beams, and the stanchions of each tier are always located immediately over one another. Thus the whole center line of deck framing is supported and tied longitudinally and to the keel structure.

In some vessels the ends of stanchions are kneed to ..ck frames and to keelson, and in others they are secured with deck straps. (See Fig. 50 for method of using strap at upper end and knee at keelson.)

Sometimes a system of supports and diagonal fore-and-aft bracing, or trussing, is used between orlop deck beams and keelson, and sometimes a fore-and-aft longitudinal bulkhead with openings through it, at stated intervals, extends from keelson to orlop deck beams. The supports above orlop deck are in both these methods of construction stanchions fitted as already described.

In some steam-driven vessels longitudinal stringers are located in line with the outboard sides of hatch openings and practically form a part of hatch framing. In vessels constructed in this manner it is usual to place sister keelsons immediately below these side stringers and to erect stanchions between the sister keelsons and longitudinal stringers.

In many cases it is necessary to join two or more pieces of timber together to form a deck beam. When this is done the beam is termed a two or three-piece beam and the scarphing is done in one of the ways shown on Plate VIIe.

When laying out a scarph for a deck beam it is essential that length of scarph be sufficient to insure that joint (..arph) has ample strength when fastenings are in ..ce.

Below I give a brief list of suitable dimensions for beam scarphs and fastenings of beams about 40 feet in length.

Name	Orlop Deck Beams	Lower Deck Beams	Upper Deck Beams	Quart'd Deck and Forec'tle Beams
Length of scarph	8 feet	7—8 ft.	7—8 ft.	8—7 ft.
Depth of lip	3 inches	3 inches	3 inches	3 inches
Bolts in lip	2 of 7/8"	2 of 7/8"	2 of 3/4"	2 of 5/8"
Bolts in middle	3 of 1 1/4"	3 of 1 1/4"	3 of 1"	3 of 7/8"
Through Ends	4 of 1 1/2"	4 of 1 3/4"	4 of 1 1/4"	4 of 1 1/4"

81. *Fastening the Knees and Deck Beams*

Deck beams are fastened to shelf with bolts that pass through beams into shelf and are riveted along underside of shelf.

The hanging knees are fitted to underside of beams and to side of vessel and fastened with through rivets driven at varying angles. On Fig. 50 knee fastenings are clearly shown. When designating parts of hanging knees the proper terms to use are:

The Arm.—Meaning by this the end of knee fitted against beam.

The Body.—Meaning the portion of end of knee fitted against clamps and side of vessel.

Lodge or lodging knees usually have their arms fitted against side of beam and body fitted against clamp. The fastenings of lodge knee arms are bolts that pass through arm of knee and beams, and of body bolts that pass through knee, clamp and frame.

Fastenings of knees are designated as being either in-and-out, or fore-and-aft, depending upon whether they are driven through side of vessel or through the beam. Those used to fasten body of knee to side are termed in-and-out bolts and those used to fasten arm of knee to beams are termed fore-and-aft.

There are usually from five to seven in-and-out bolts

Fig. 47. Treenails Ready to Drive Into Ceiling Frame and Planking

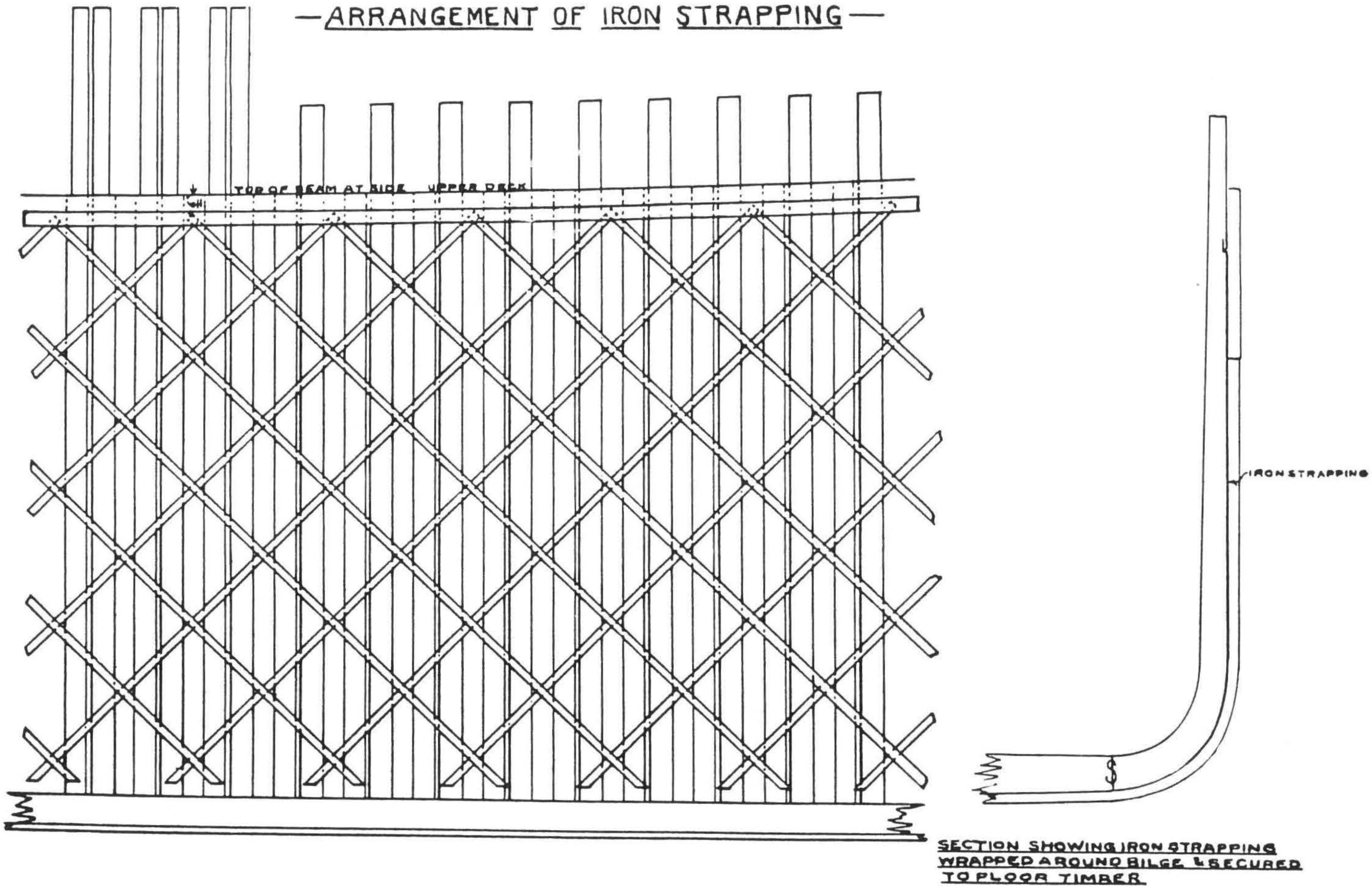


Fig. 49. Diagonal Straps

used in a hanging knee, each bolt being driven at an angle that will cause it to take the *shortest* distance between knee and outside of planking. All but one or two of these bolts are driven from the outside and clenched on inside, and all in-and-out fastenings are driven, and knee secured to side of vessel, before the fore-and-aft fastenings are driven and secured. This is done to insure that knee fits snug against side of vessel.

The fore-and-aft fastenings should consist of from three to five bolts passing through both knee and beam.

The in-and-out bolts in lodging knees should never be fewer than one in each timber, and the knees should be sufficiently long to cross at least four timbers. If an exceptionally strong job of work is desired the fore-and-aft bolt fastenings should be reinforced by using circular coaks. On Table VIII[1] is entered the minimum number of pairs of hanging knees to use in vessels of named tonnage.

TABLE VIII[1]

NUMBER OF HANGING KNEES

Tons	To Hold Beams Pairs	To Upper Deck Beams Pairs	Tons	To Hold Beams Pairs	To Upper Deck Beams Pairs
150	—	4	600	10	14
200	4	6	650	10	15
250	5	7	700	11	16
300	6	8	750	11	17
350	7	9	800	12	18
400	8	10	900	13	20
450	8	11	1000	14	22
500	9	12	1100	15	24
550	9	13	1350	17	26

8t². *The Framing of Decks*

The framing of deck consists of athwartships beams, half-beams, longitudinal carlings and ledges. Dimensions of beams vary with their length. On Table VIII[2] is given dimensions of beams, and method of framing is clearly shown on Figs. 27, 28, 42a and 50.

In general one half-sized beam is placed between each two main beams except in spaces between beams that form the hatchways and around masts, where there are generally two half-beams placed between each two beams.

All deck beams should be crowned, those of the upper decks having the greatest amount of crown.

Deck beams are crowned because the crown causes water to quickly flow to the waterways, where it passes clear through the scuppers and in addition to this transverse strength is increased by crowning beams, especially if, as is sometimes done, the beams are crowned while being placed in position.

It is advantageous to let ends of beams into shelf in the manner shown on Fig. 42a.

8t³. *Framing of a Hatchway*

Fig. 27 clearly illustrates the proper way to frame a hatchway of a medium-sized vessel. In larger vessels the center line longitudinal deck stringer mentioned in paragraph 8th extends longitudinally across hatchway

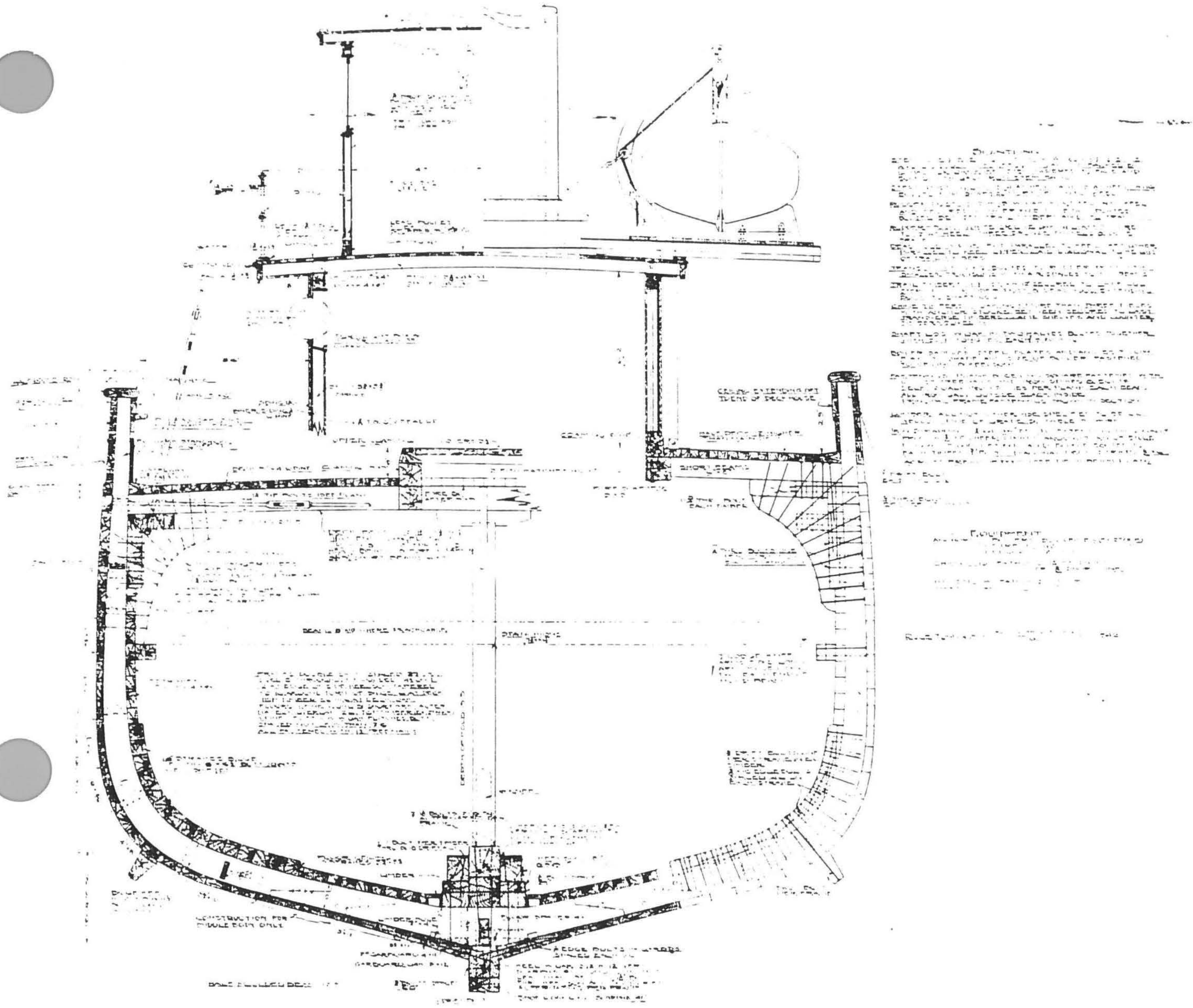


Fig. 50. Construction Plan of Section of Steam Trawler by Cox & Stevens

practically dividing it into two portions, and when the side longitudinal stringers are used they form a support for the coaming.

8t⁴. *Framing of Mast Partners*

Mast partners is the name given to the framing around hole in deck through which mast passes. The framing must be strong and solid because it has to withstand the strains of both mast and bitts that are generally placed close to a mast in sailing vessels.

On Fig. 27 is shown the usual method of framing a mast partner of a sailing vessel.

8t⁵. *Framing of Decks Around Stem and Stern*

At stem the deck framing of each deck terminates in solid block of wood, or a natural knee, called a breasthook. This breasthook is securely fastened to stem and apron and to the clamps it rests against, the fastenings through clamps passing through knightheads, frame and planking. The tops of breasthooks are rounded to the same crown that has been given to deck beams.

On Fig. 51 is shown details of forward deck framing and on Fig. 52 is shown some wood and steel knees used when framing a vessel.

Around the stern it is necessary to have solid wood to receive the deck and fastening. If the vessel has a transom stern the upper transom is always shaped and rabbeted to receive ends of deck planks and their fastenings. If an elliptical stern the upper piece of stern framing is shaped to receive deck ends and their fastenings.

8t⁶. *Framing of Decks under Deck Winches, Capstans and Anchor Engine*

It is always necessary to strengthen the deck frame at and around locations of deck winches, anchor windlass and capstans. This is done by filling in between the deck

beams and supporting this filling by bolting longitudinal planks to the deck beams it crosses. The filling and planks should extend some distance outside the space that will be occupied by deck windlass or other piece of equipment, and of course the filling must cover the entire space between under side of deck and upper surface of the supporting planks. The deck is laid on this filling and after deck is finished and caulked wood foundation timbers are fitted on deck, the upper surface of these being arranged to receive the holding down bolts of windlass or other piece of equipment.

When the piece of equipment is very heavy supporting stanchions are added under the deck beams.

8u. The Waterways

The waterways are pieces of timber that rest on deck beams and fit in angle made by deck beams and side of vessel. Waterways extend from forward to after ends of each deck, are worked to the shape of inside of vessel and are securely fastened to deck beams and shelf or clamps beneath the beams; they should be edge-bolted into frames.

In some vessels filling-in pieces are fitted to fill the space between shelf and top of beams and from side of ship to where inner edge of waterway will be located. When this is done the waterways can be fastened to shelf between beams and thus additional strength is gained.

Waterways are always made of thicker material than the deck, and scarphs of waterways should always be vertical, have nibbed ends, or be hooked, and be edge-bolted.

On Fig. 28 is shown a detail of waterway construction and method of fastening, and on Figs. 26, 53, and 54 waterways are shown fitted in place alongside frames.

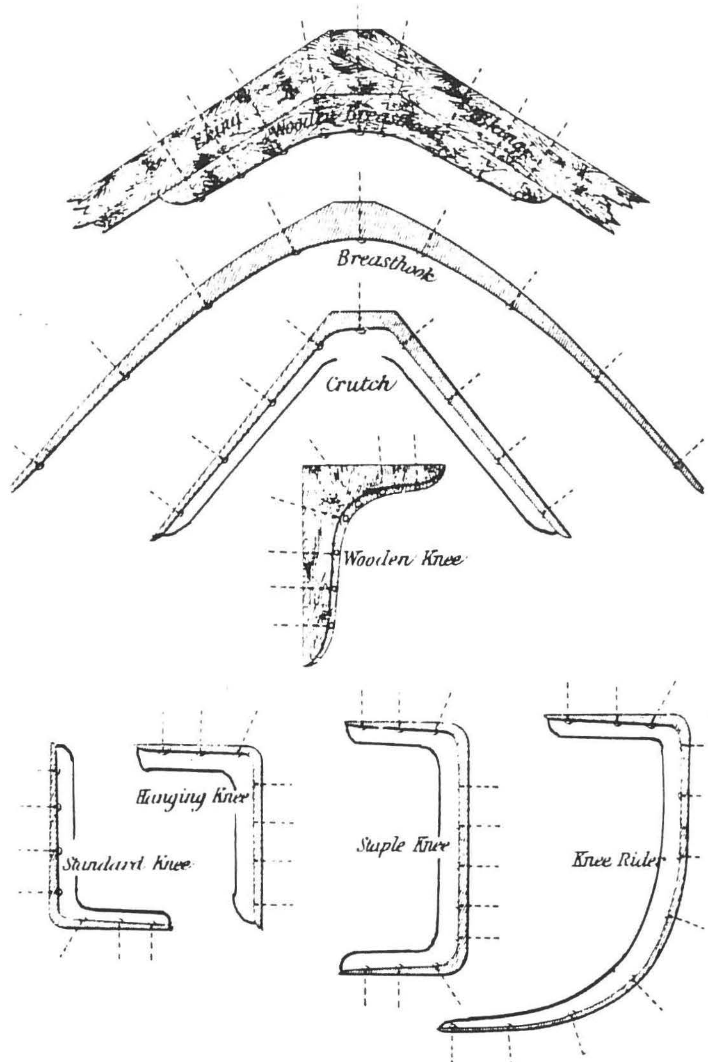


Fig. 52

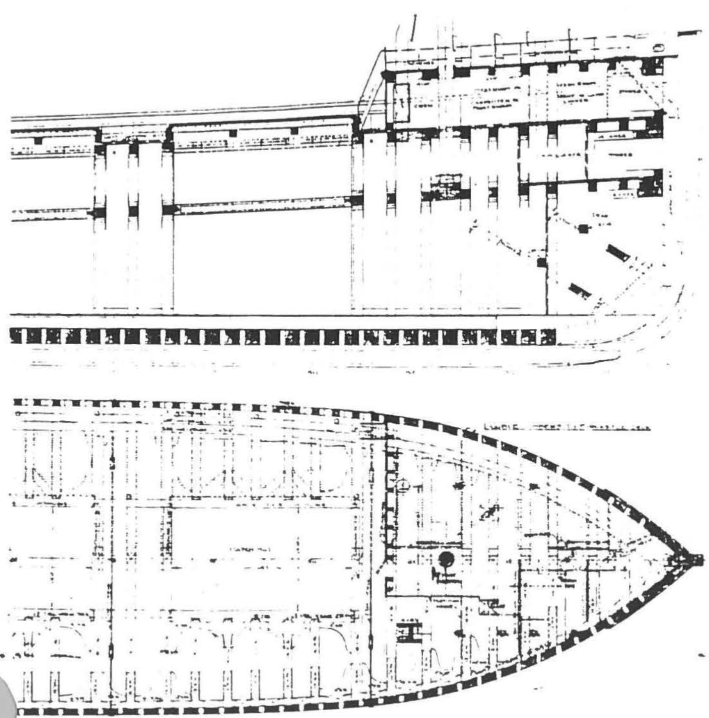


Fig. 51. Bow Framing

8u¹. *Lock or Thick Strakes*

These are strakes of decking that adjoin the waterways. They are thicker than deck proper and are joggled over beams. This joggle is clearly shown on Fig. 42a. These strakes extend from bow to stern and are fastened vertically with two fastenings through every beam, and horizontally with one bolt in every second timber. (Note it is usual to leave room for these fastenings by omitting a fastening from every frame to which thick strakes will be fastened.)

8u². *Decking*

The upper or main deck planking should be composed of clear straight-grained material put on in greatest obtainable lengths. Deck planks are usually worked fore-and-aft and the laying is begun at or near to center line of vessel. The ends of deck planks that butt against thick or lock strakes of waterways should be let into thick strake about 2 inches, thus eliminating a feather edge and giving a good seam for caulking. On Fig. 55 the ends of deck planks are shown let into thick strake

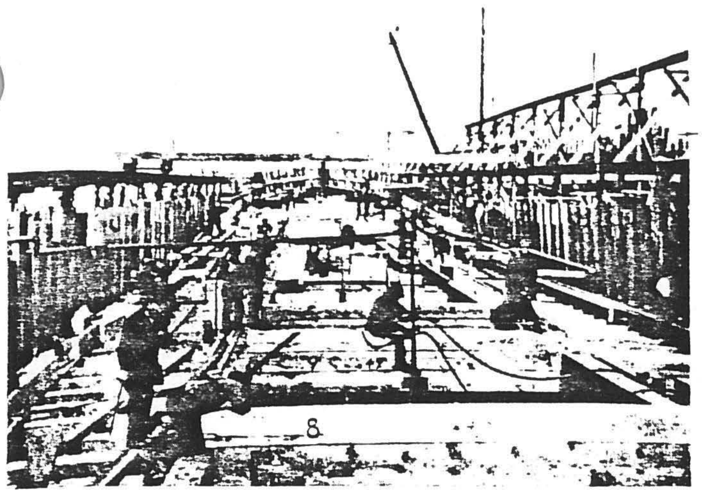


Fig. 53. Deck Framing and Waterways

of waterway. Deck planks are laid with seams for caulking and are fastened to beams with at least two spikes into each beam.

Butts are square cut on center of a beam and should be bolted. Rules for spacing butts of deck planks and caulking seams conform to those laid down for outer planking of frames.

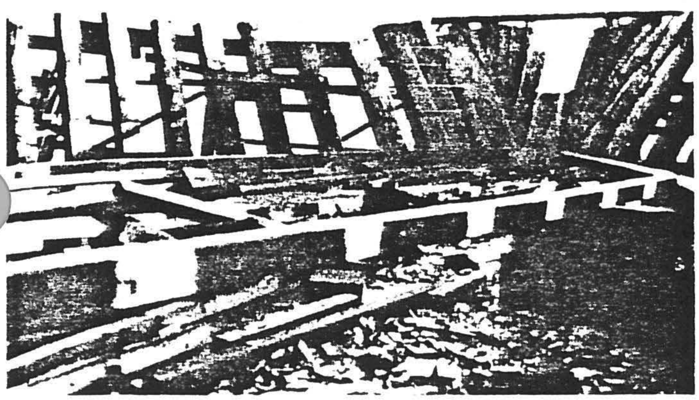


Fig. 54. Showing Waterways in Main Deck Forward of Auxiliary Schooner

TABLE VIII[2]

SIDING AND MOULDING OF BEAMS

Length of Beam Amidships Ft.	Hold Beams Sided and Moulded In.	Hold Beams Moulded at Ends In.	Deck Beams Sided and Moulded In.	Deck Beams Moulded at Ends In.
10	....	....	4½	3¾
11	....	....	5	4
12	....	....	5¼	4¼
13	....	....	5½	4½
14	....	....	5¾	4¾
15	8	6¾	6¼	5¼
16	8½	7	6½	5½
17	8¾	7½	6¾	5½
18	9¼	7¾	7	5¾
19	9½	8	7¼	6
20	10	8½	7½	6¼
21	10¼	8¾	7¾	6½
22	10½	9	8	6½
23	11	9¼	8¼	6¾
24	11¼	9½	8½	7
25	11¾	9¾	8½	7¼
26	12	10	8¾	7¼
27	12¼	10¼	9	7½
28	12½	10½	9	7½
29	12¾	10¾	9¼	7¾
30	13	11	9½	8
31	13¼	11¼	9½	8
32	13½	11½	9¾	8¼
33	13¾	11½	10	8¼
34	14	11¾	10	8½
35	14¼	12	10¼	8½
36	14½	12¼	10¼	8½
37	14¾	12½	10½	8¾
38	15	12½	10½	8¾
39	15¼	12¾	10½	9
40	15½	13	10¾	9

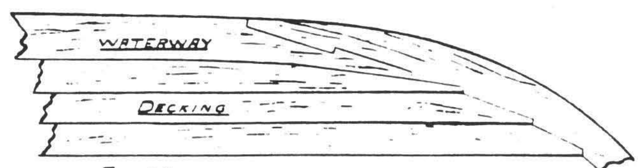


FIG 55

Fig. 55. Ends of Deck Let Into Waterways

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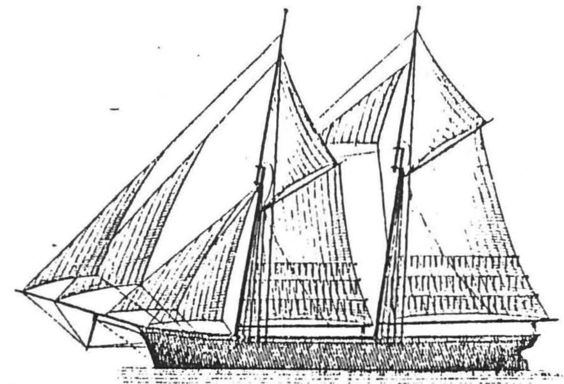
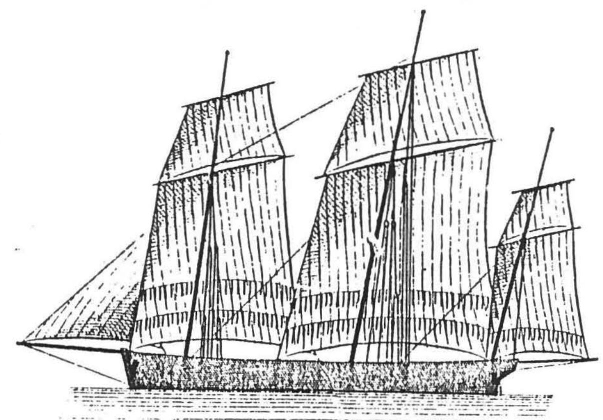
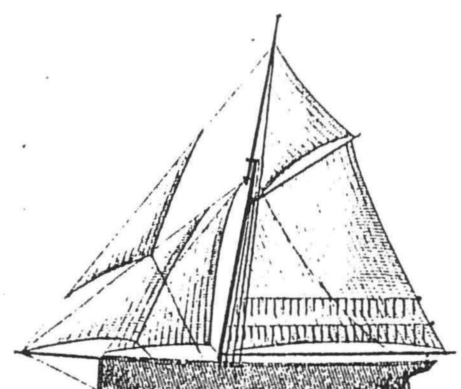


FORE & AFT-SCHOONER-GOËLETTE FRANCHE-VOR & HINTER SCHOONER.



CHASSE - MARÉE.



CUTTER — CÔTRE — KUTTER.

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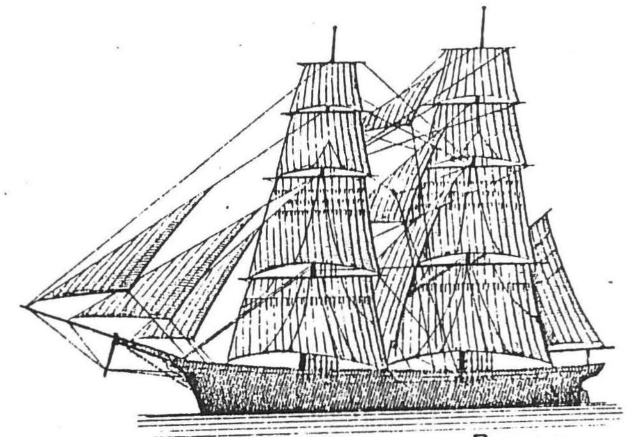
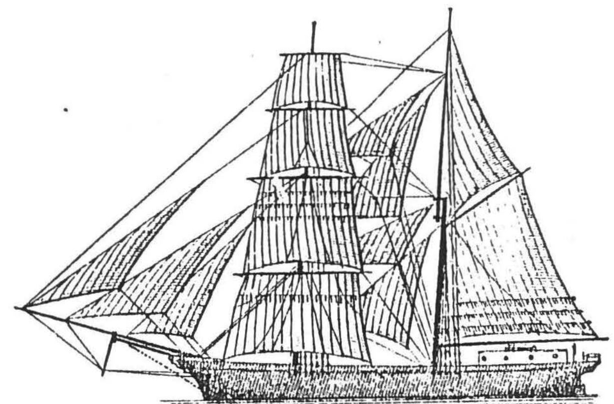
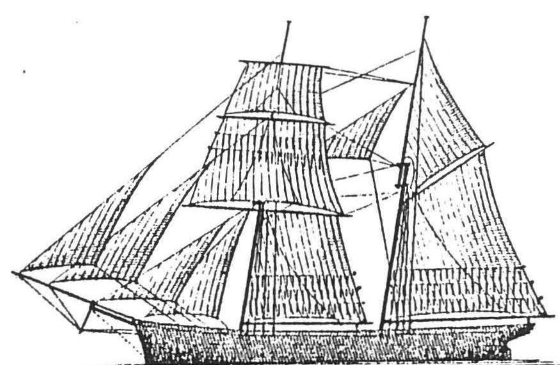
DIFFERENTS GRÉEMENTS DE NAVIRES.
VERSCHIEDENE TAKELAGEN VON SCHIFFEN



BRIG — BRICK — BRIGG.

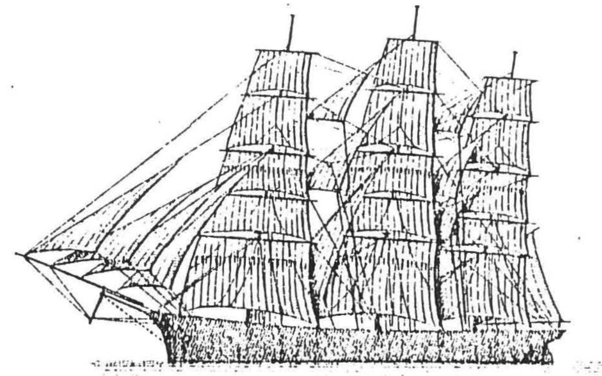


BRIGANTINE — BRIGANTIN — SCHOONER-BRIGG.

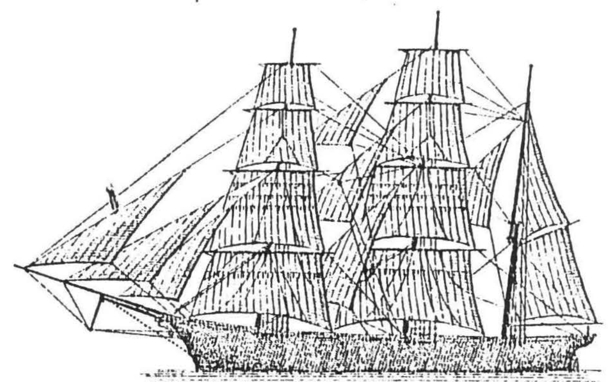


TOPSAIL-SCHOONER-GOÉLETTE CARRÉE-TOPSEGEL-SCHOONER.

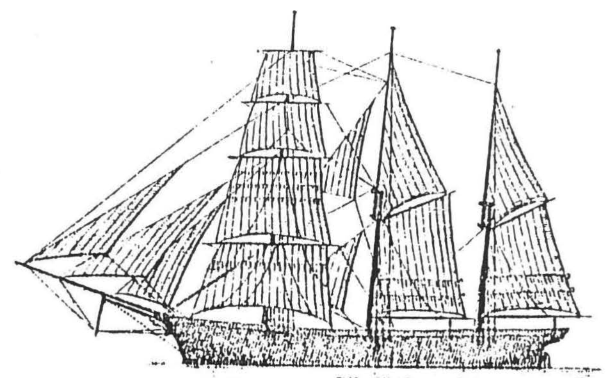
DIFFERENT RIGS OF VESSELS.
DIFFERENTS GRÉEMENTS DE NAVIRES.
VERSCHIEDENE TAKELAGEN VON SCHIFFEN.



SHIP – TROIS MÂTS – VOLLSCHIFF.



BARQUE – BARQUE – BARK.

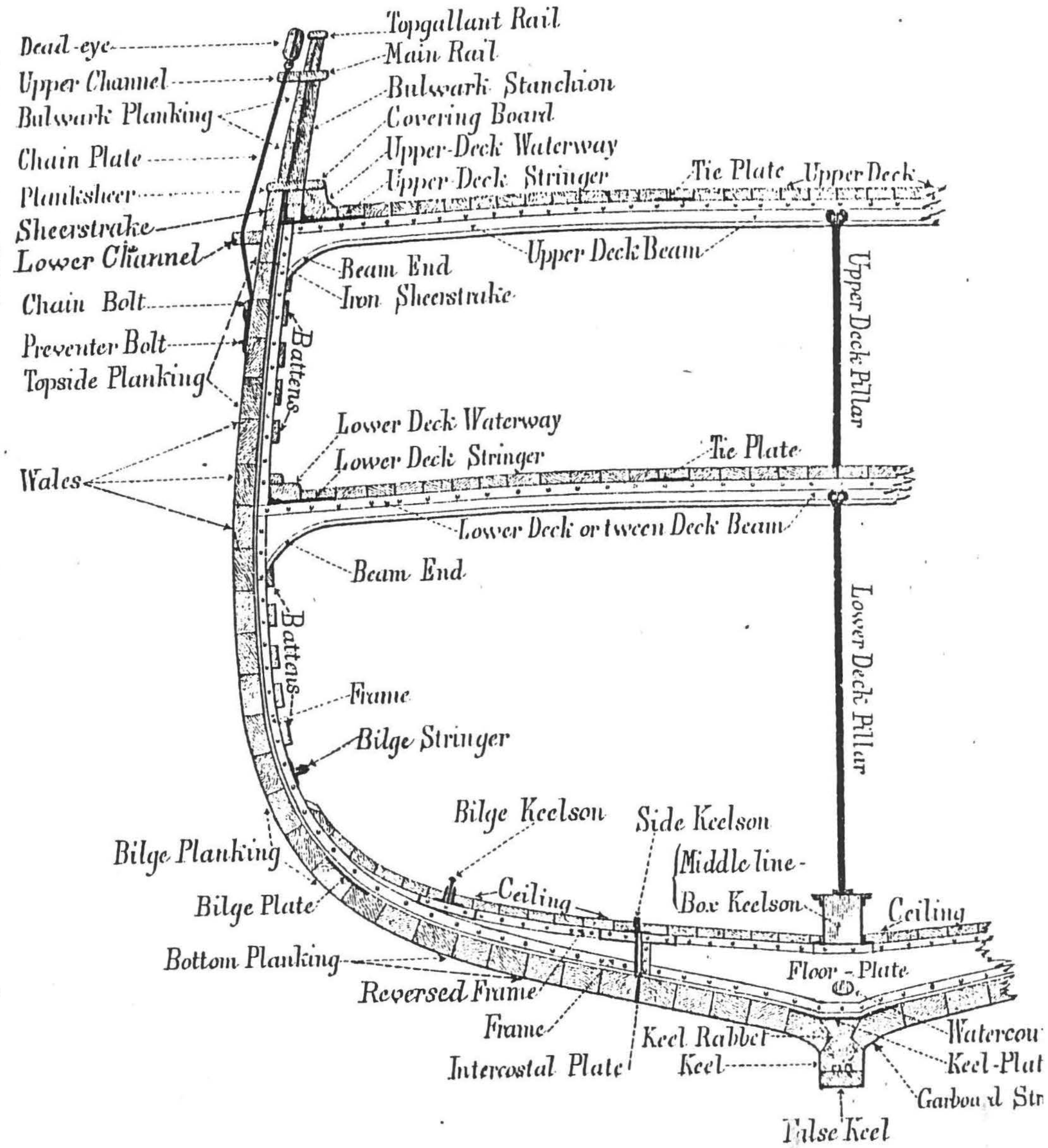


BARQUENTINE — BARQUENTIN — SCHOONER BARK.

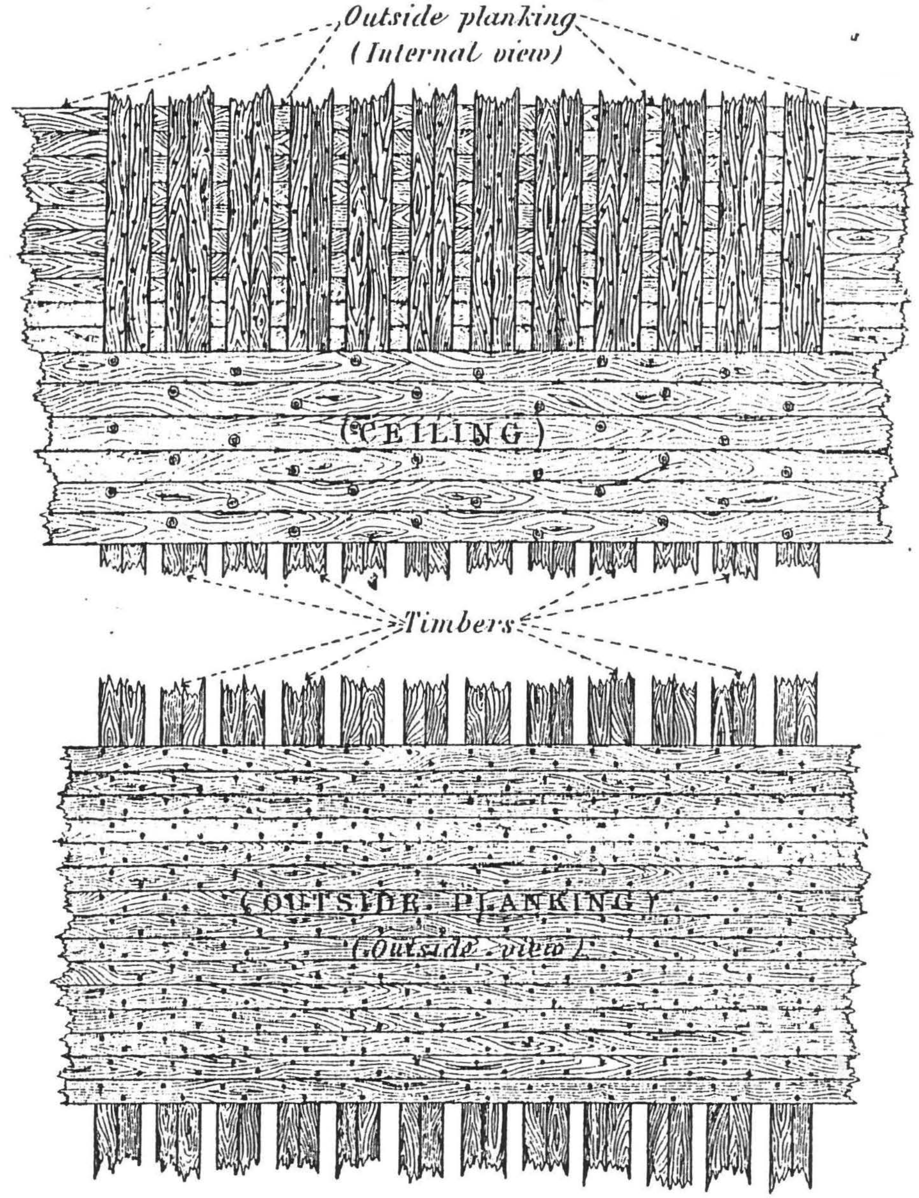
MIDSHIP SECTION OF A COMPOSITE SHI

COUPE AU MAITRE D'UN NAVIRE COMPOSITE.

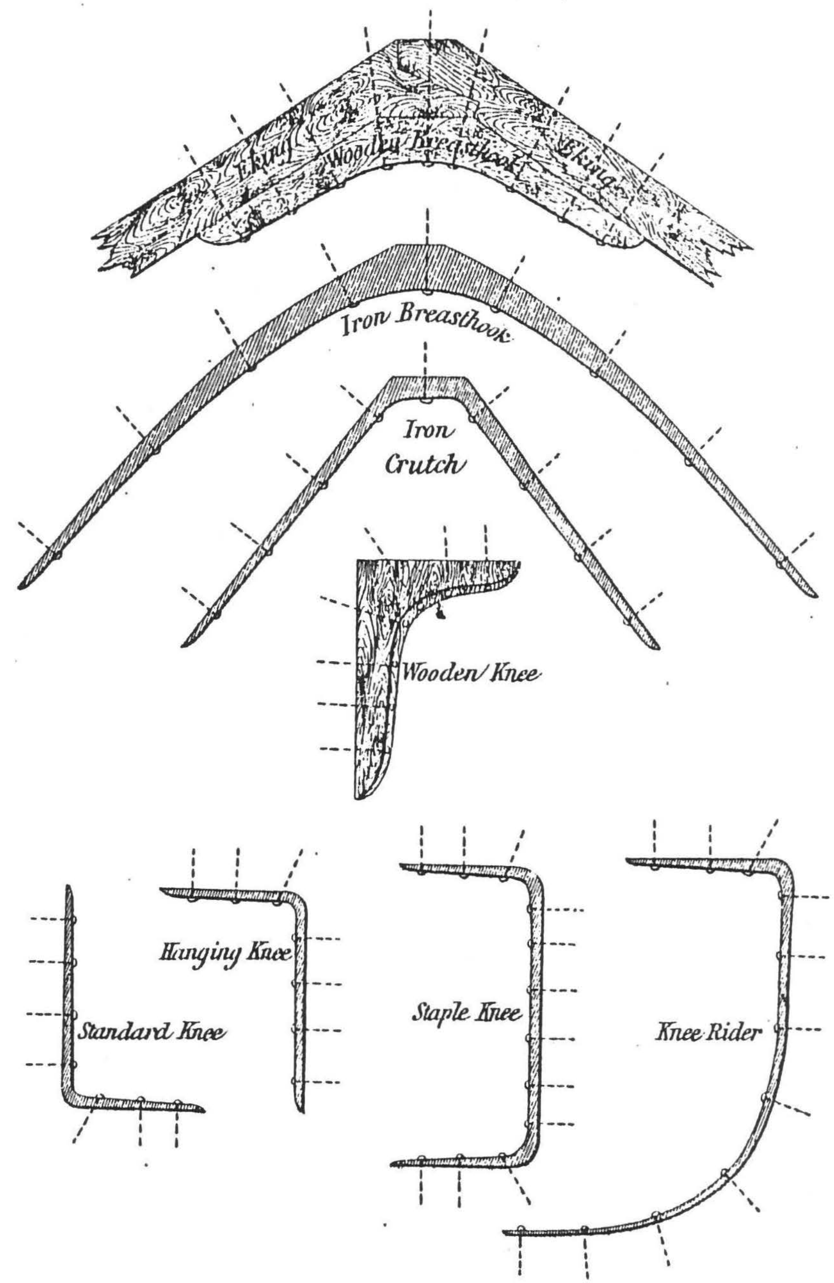
HAUPTSPANT - QUERSCHNITT EINES COMPOSITIONS SCHIFFES.



EW OF OUTSIDE PLANKING, TIMBERS AND CEILIN(
JE DE BORDÉ EXTÉRIEUR, MEMBRURE ET VAIGRAGE.
ANSICHT VON AUSSENPLANKEN, INHÖLZERN UND WEGERUNG.

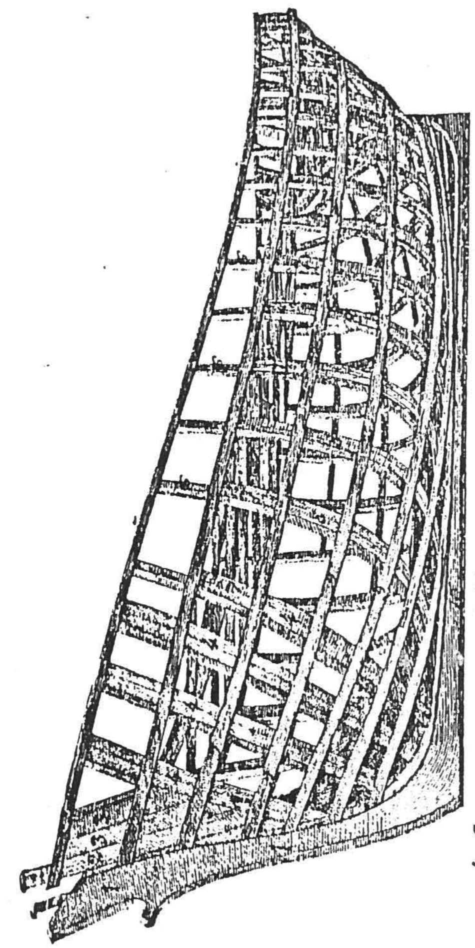


BREAST-HOOKS, KNEES &c. _ GUIRLANDES, COURBES &A. _ BUGBÄNDER, [illegible] &A.



Satin wood	Bois de satin.	Atlasholz.
Spruce	Spruce.	Spruce; Schwarz-Fichtenholz.
Spruce Fir	Sapin spruce.	Sprossenfichtenholz.
Stringy Bark	Stringy Bark.	Stringy Bark.
Tamarack	Tamarack.	Tamarack.
Tallow-wood	Arbre à suif.	Talgbaumholz.
Teak	Teck.	Teckholz.
Thingam	Thingam.	Thingam.
Tropical-hard-wood	Bois dur des tropiques.	Tropisches hartes Holz.
Tulip-wood	Tulipier.	Tulpenbaumholz.
Turpentine	Thérébinthe.	Terpentinbaumholz.
Venatica	Venatica.	Venatica.
Walnut	Noyer.	Nussbaumholz, Walnussholz.
Black Walnut	Noyer noir.	Schwarz-Walnussholz.
Yew	If.	Eibenbaumholz.

FRAMING OF A WOODEN VESSEL.
MEMBRURE D'UN NAVIRE EN BOIS.
GERIPPE EINES HÖLZERNEN SCHIFFES.

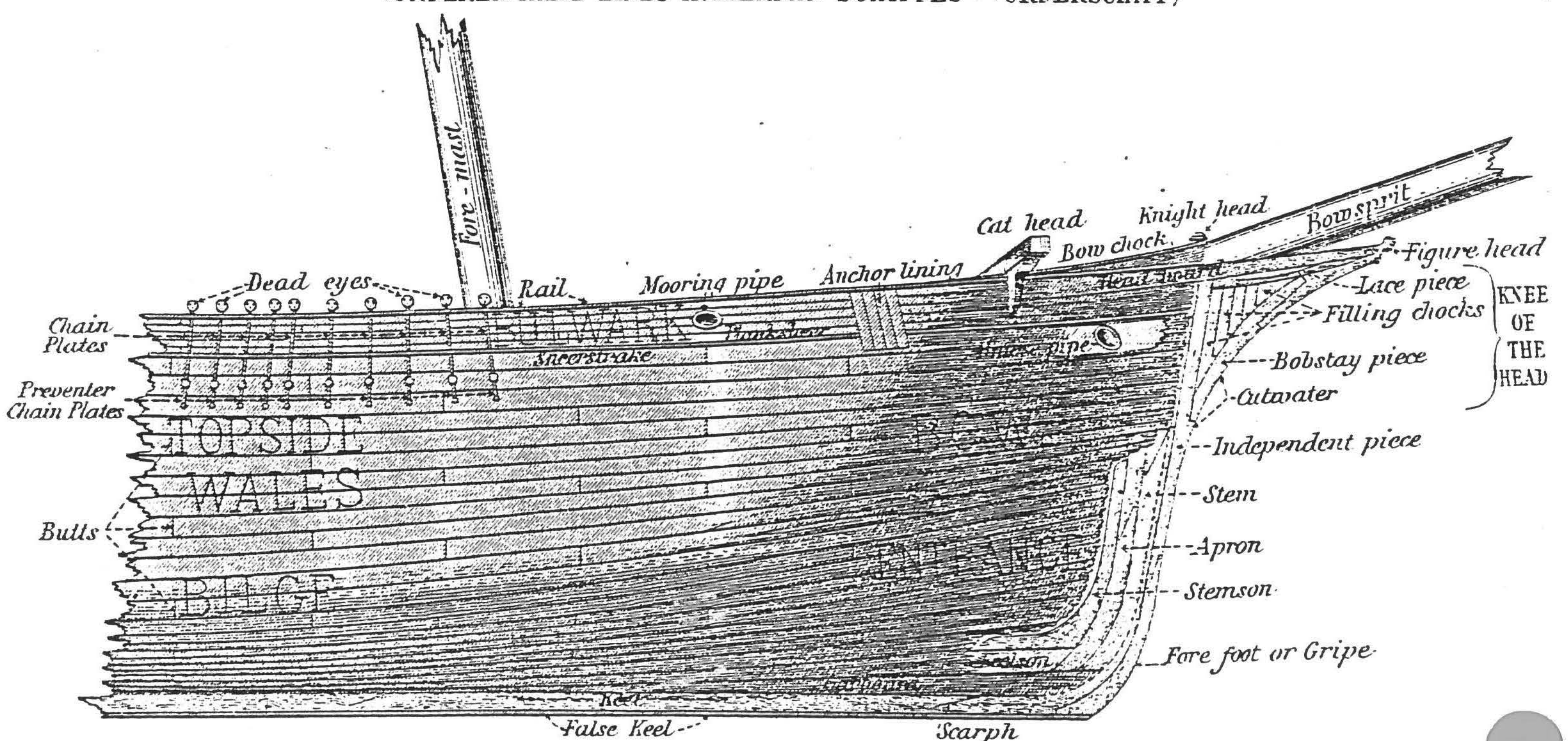


1. Stem
2. Knight-heads
3. Hawse-timbers
4. Cant-timbers
5. Main-rail
6. Bulwark Stanchions
7. Top-timbers
8. Frames
9. Planks
10. Keel

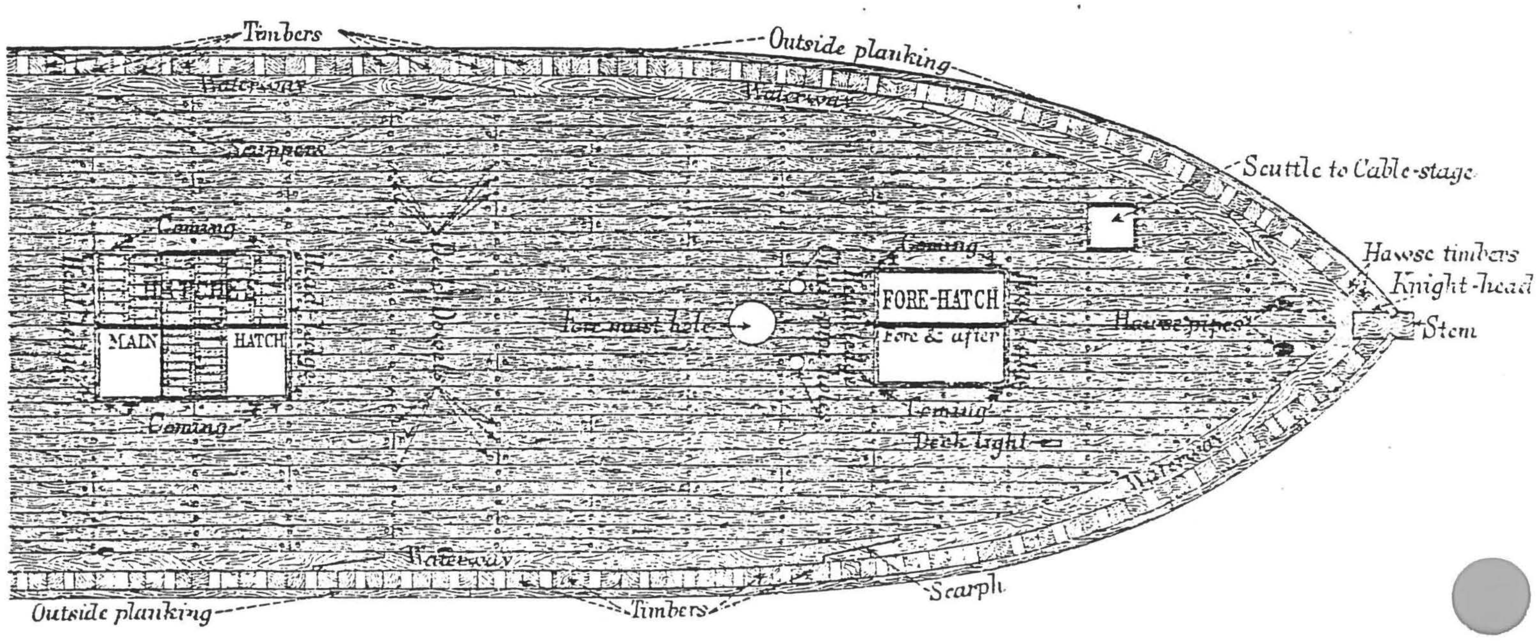
FORE BODY OF A WOODEN SHIP.

PARTIE AVANT D'UN NAVIRE EN BOIS.

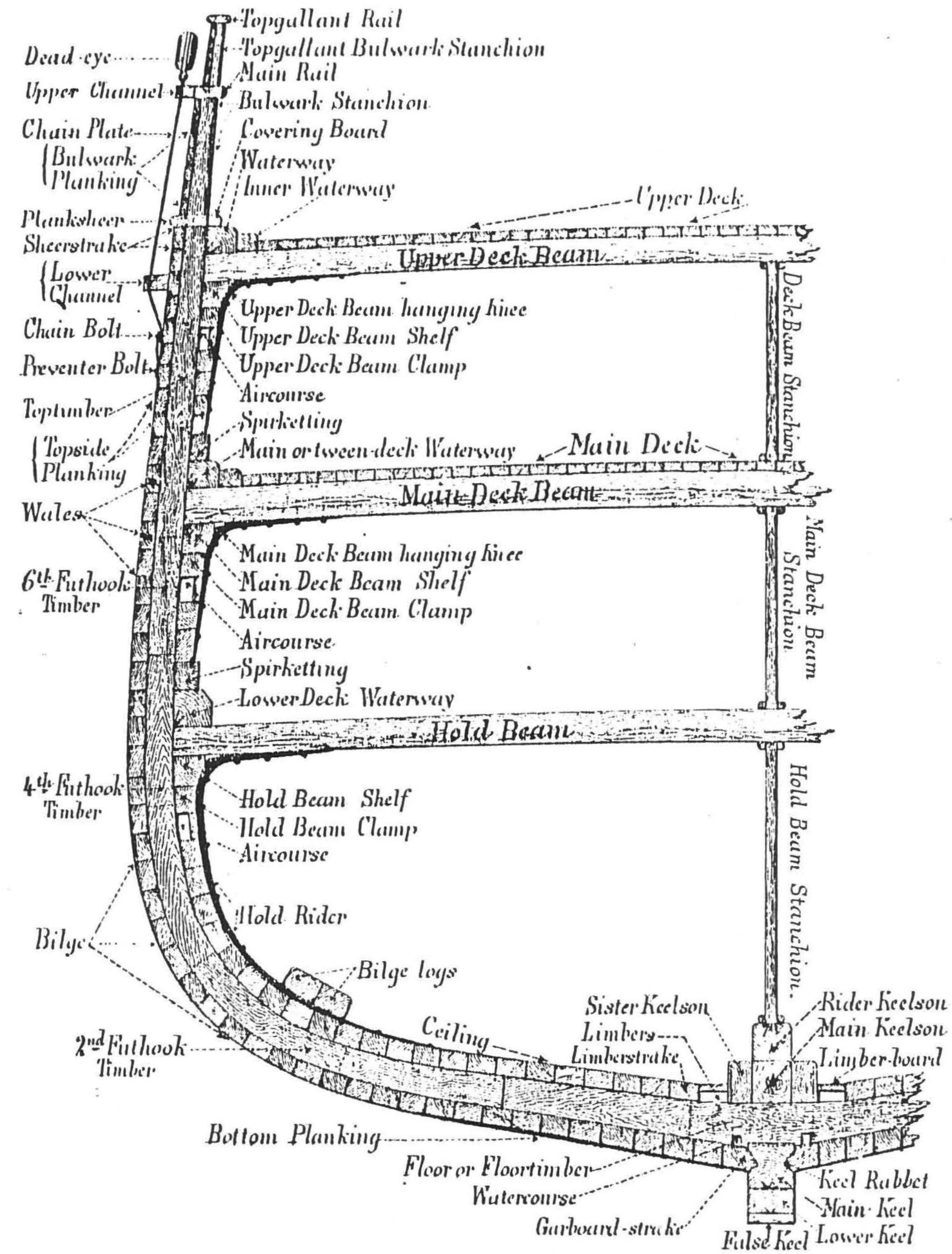
VORDERER THEIL EINES HÖLZERNEN SCHIFFES (VORDERSCHIFF)



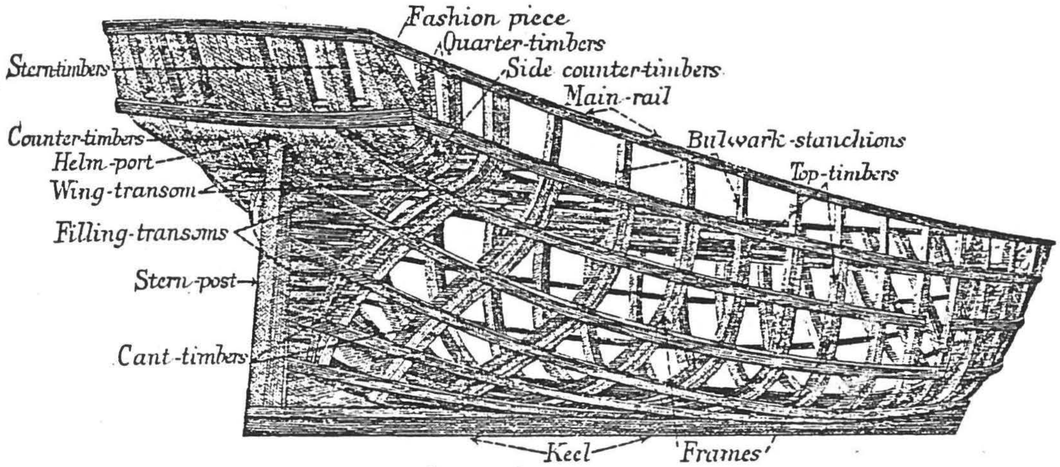
DECK-PLAN OF A WOODEN SHIP
PLAN DE PONT D'UN NAVIRE EN BOIS
DECKPLAN EINES HÖLZERNEN SCHIFFES.



MIDSHIP SECTION OF A WOODEN SHIP.
COUPE AU MAITRE D'UN NAVIRE EN BOIS.
HAUPTSPANT-QUERSCHNITT EINES HÖLZERNEN-SCHIFFES.



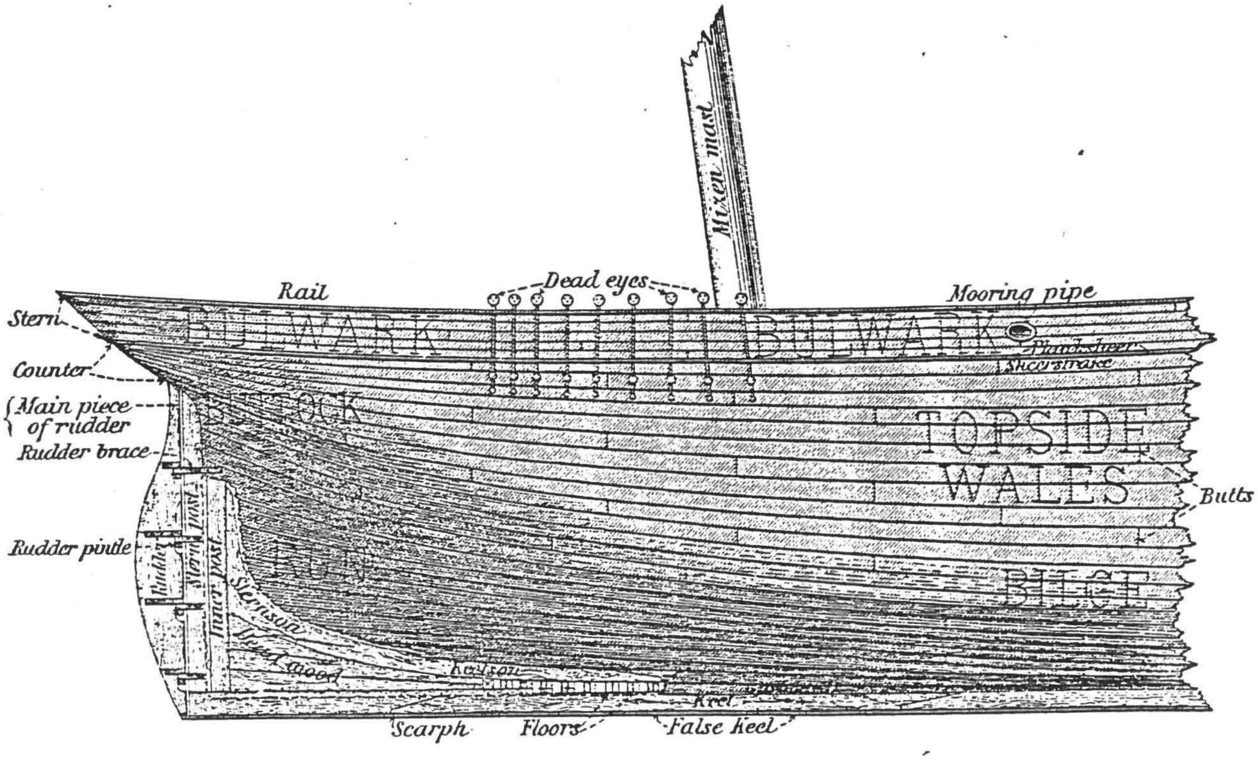
FRAMING OF A WOODEN VESSEL.
MEMBRURE D'UN NAVIRE EN BOIS.
GERIPPE EINES HÖLZERNEN SCHIFFES.



AFTER BODY OF A WOODEN SHIP.

PARTIE ARRIÈRE D'UN NAVIRE EN BOIS.

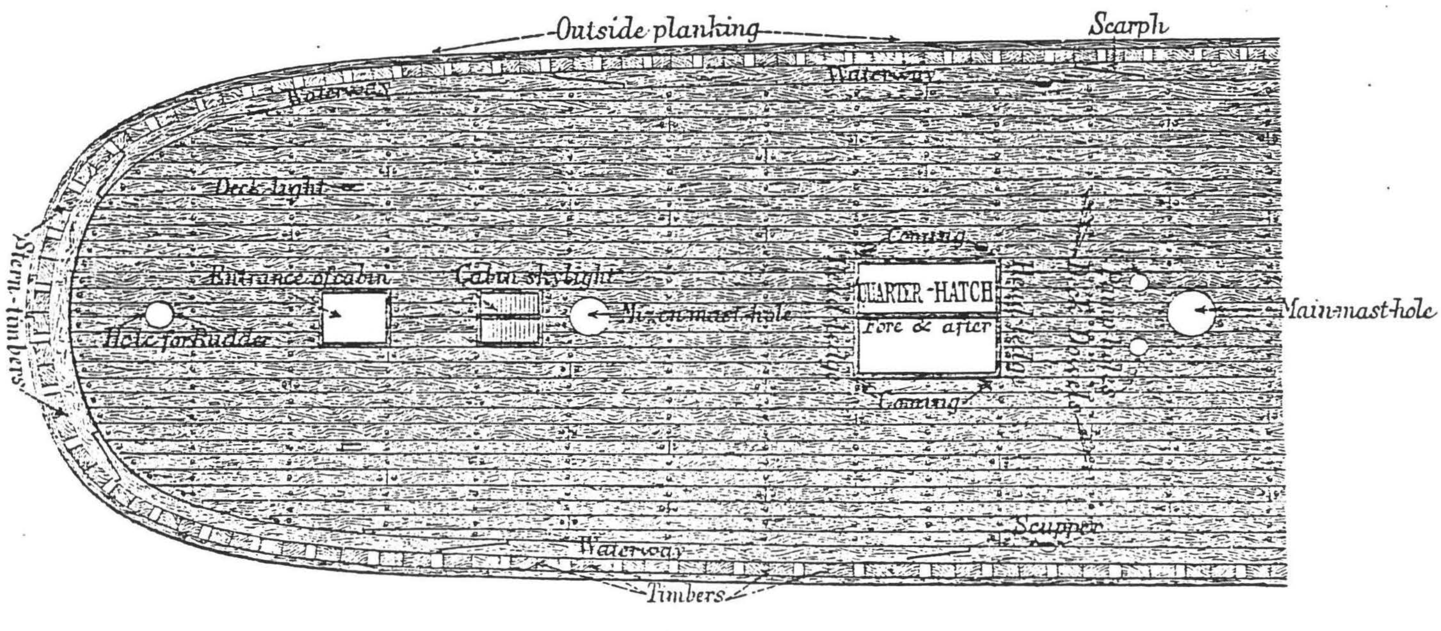
HINTERER THEIL EINES HÖLZERNEN SCHIFFES (HINTERSCHIFF



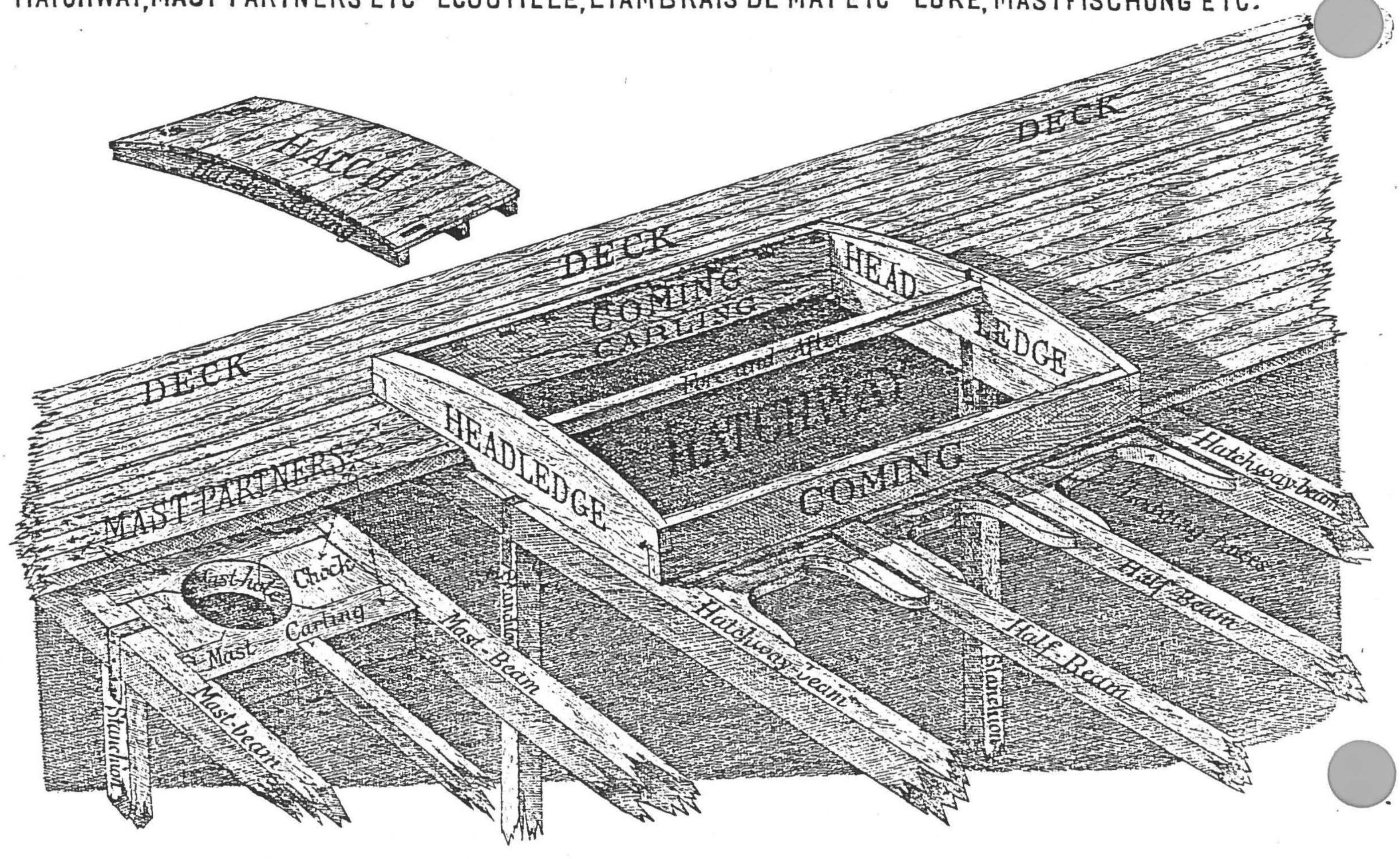
DECK-PLAN OF A WOODEN SHIP

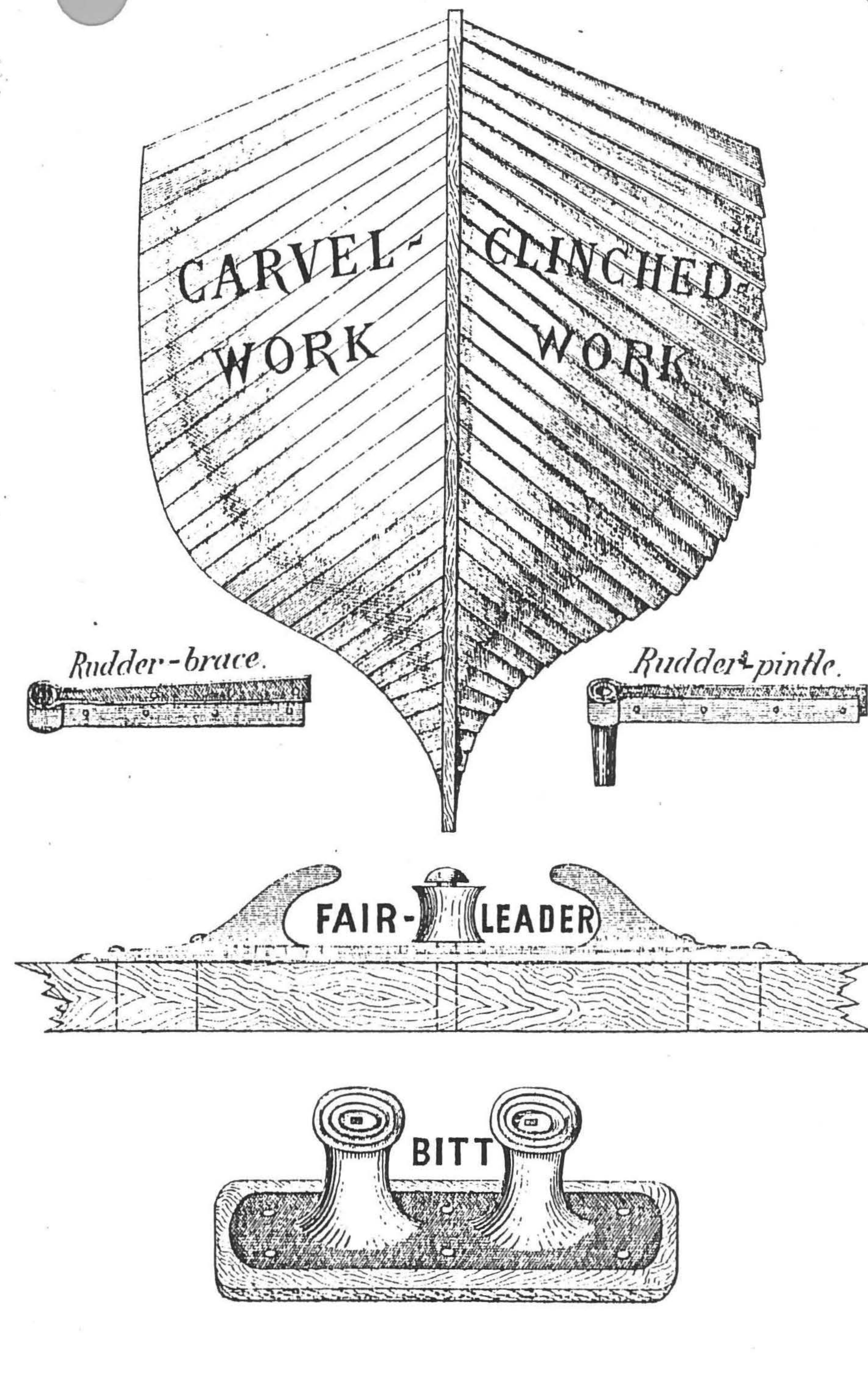
PLAN DE PONT D'UN NAVIRE EN BOIS

DECKPLAN EINES HÖLZERNEN SCHIFFES.



HATCHWAY, MAST-PARTNERS ETC — ÉCOUTILLE, ÉTAMBRAIS DE MÂT ETC — LUKE, MASTFISCHUNG ETC.




CARVEL-WORK
CLINCHED-WORK
Rudder-brace.
Rudder-pintle.
FAIR-LEADER
BITT

Chapter--VII

Joints and Scarphs

In ship construction it is necessary to join together a number of pieces of wood in such a manner that the strength of joints will at least equal the strength of material used.

The meeting place of two pieces of wood is called the *joint* and the joint is circumscribed by the lines which mark the intersection of the faces of one piece with the other.

The simplest and easiest joints to make are those in which the bearing faces are planes of the same size and shape in relation to the planes of the axes.

The putting together of two pieces of wood may be done in three ways:

1st.—They may meet and form an angle.

2d.—Two pieces may be joined in a right line by lapping and indenting the meeting ends on each other. This is called *scarphing.*

3d.—The two pieces may be joined longitudinally, the joint being secured by covering it on opposite sides by pieces of wood, or metal, bolted to both beams. This is called *fishing.*

7a. Joints That Form an Angle

Should two pieces of wood that meet and form an angle be joined by simple contact of the end of one piece with its bed on the other, the pieces are said to abut, and the joint is called a plain joint. This method of joining does not prevent one piece sliding on the other, unless it is fastened with nails or bolts, and even when these are used the joint will be a very insecure one.

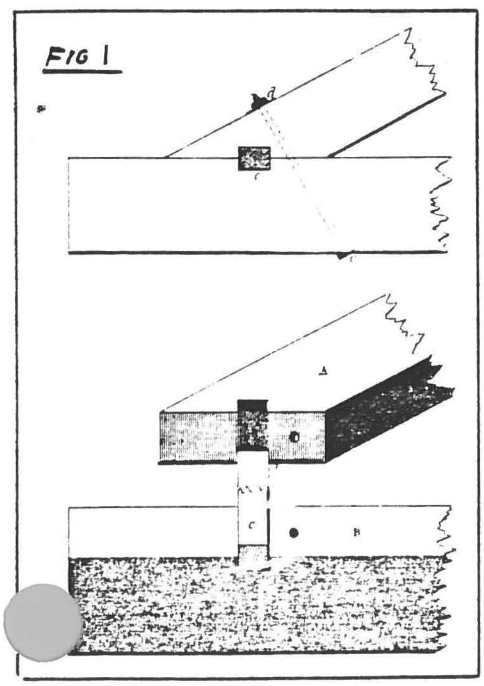
Plate VIIa Illustrations

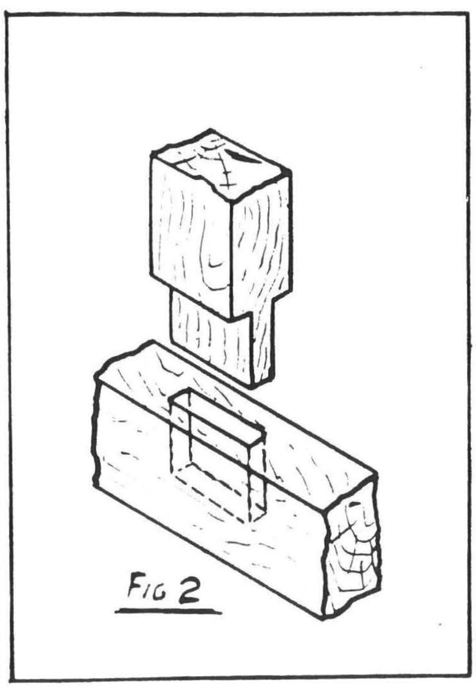
Fig. 1 shows the simplest means of obtaining resistance to sliding by inserting the piece *C* in notches cut in both pieces. On the upper view of joint is shown the proper mode of securing joint by a bolt. A stronger but more costly method of joining is the mortise and tenon, and as this is the principle of a large number of joints, I will describe it at length.

The simplest case of a mortise and tenon joint is when two pieces of wood meet at right angles. Such a joint is shown on Fig. 2.

The tenon is formed at the end of one piece in the direction of its fibres and a mortise of exactly the same size and form as the tenon is hollowed in the face of the other piece. The sides of the mortise are called the cheeks, and the square parts of the piece from which the tenon projects, and which rest on the cheeks, are called the shoulders. As the cheeks of the mortise and the tenon are exposed to the same amount of strain, it follows that each should be equal to one-third the thickness of timbers in which they are made.

The length of a tenon should equal the depth of the mortise, so that its end will press on bottom of mortise





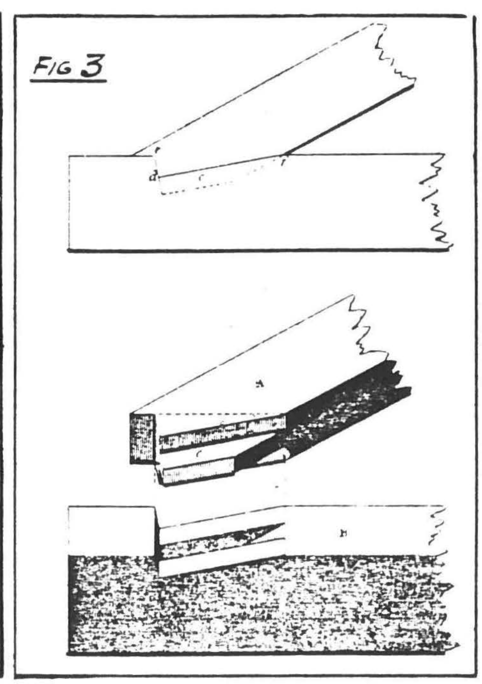


Plate VIIa

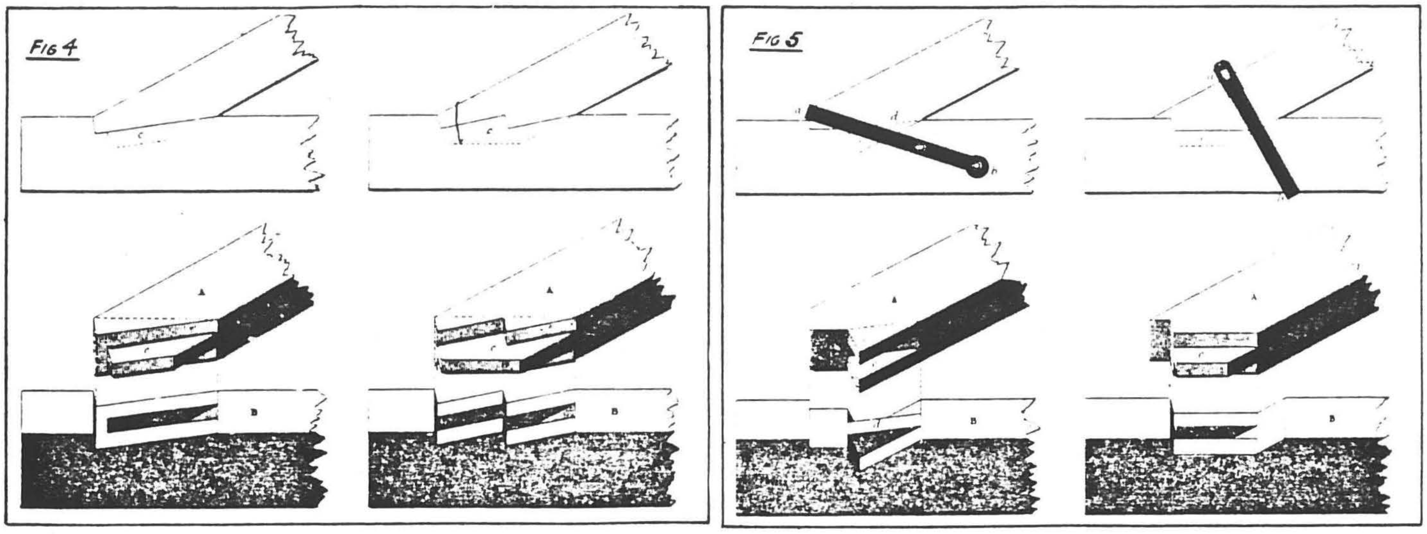


Plate VIIb

when shoulders bear on the cheeks. In practice this perfection of joining cannot be obtained, so the tenon is generally made slightly shorter than depth of mortise, thus enabling the shoulders to press closely upon cheeks.

When a mortise and tenon joint is cut and put together, the pieces are generally secured by a key or treenail. The key is generally a round one having a diameter equal to about one-fourth the thickness of the tenon and it is usually inserted at a distance of about one-third the length of tenon from the shoulder.

The key, however, is never depended upon as a means of securing the joint, because joints of this kind should be so closely fitted that they will hold together without the aid of key.

The foregoing describes a simple tenoned joint when the pieces to the joint are at right angles to each other.

When the pieces to be joined are not at right angles, a more complicated method of tenoning must be used.

Fig. 1.

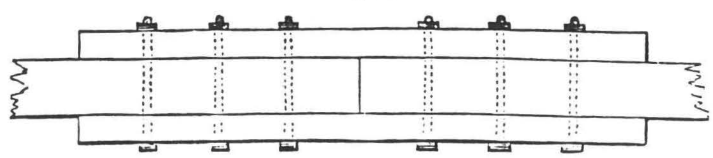


Fig. 2.

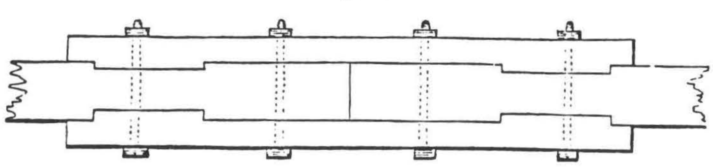


Fig. 3.

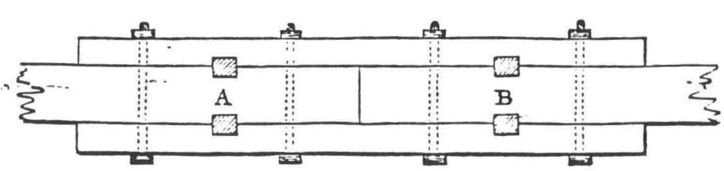


Plate VIId

This method is shown on Fig. 3.

You will note that the cheeks of mortise are cut down to form an abutment or notch, thus increasing the bearing surface and adding to the resistance to slipping.

Plate VIIb Illustrations

Fig. 4 shows other forms of this kind of joint, and on Fig. 5 I show methods of adding to resistance to slippage by using straps and bolts. Note that a steel wedge is inserted into opening of strap (*a*).

7b. Scarphs

In ship-building it is often necessary to join timbers in the direction of their length in order to secure scantlings of sufficient longitudinal dimensions. When it is necessary to maintain the same depth and width in the lengthened beam, the mode of joining is called scarphing. Scarphing can be performed in a number of different ways, but in all cases it is very necessary to consider the direction of strain to which the lengthened beam will be subjected, whether longitudinal or transverse, and to select the method that will give the maximum resistance in the direction from which the strain comes.

The following illustrations will serve to explain a number of excellent methods of scarphing and lengthening beams.

Plate VIIc Illustrations

Fig. 6 illustrates a plain scarphed joint. The ends of each piece of timber are cut obliquely and lapped and then secured by bolts that pass through plates or washers to prevent the screwing up of the nuts injuring the wood.

The strength of a scarph of this kind depends entirely upon the holding power of the bolts and the resistance to slipping is very slight.

Fig. 7 shows a similar scarph, but as the ends are indented and a key is inserted through opening cut in timbers midway from ends of scarph, the resistance to

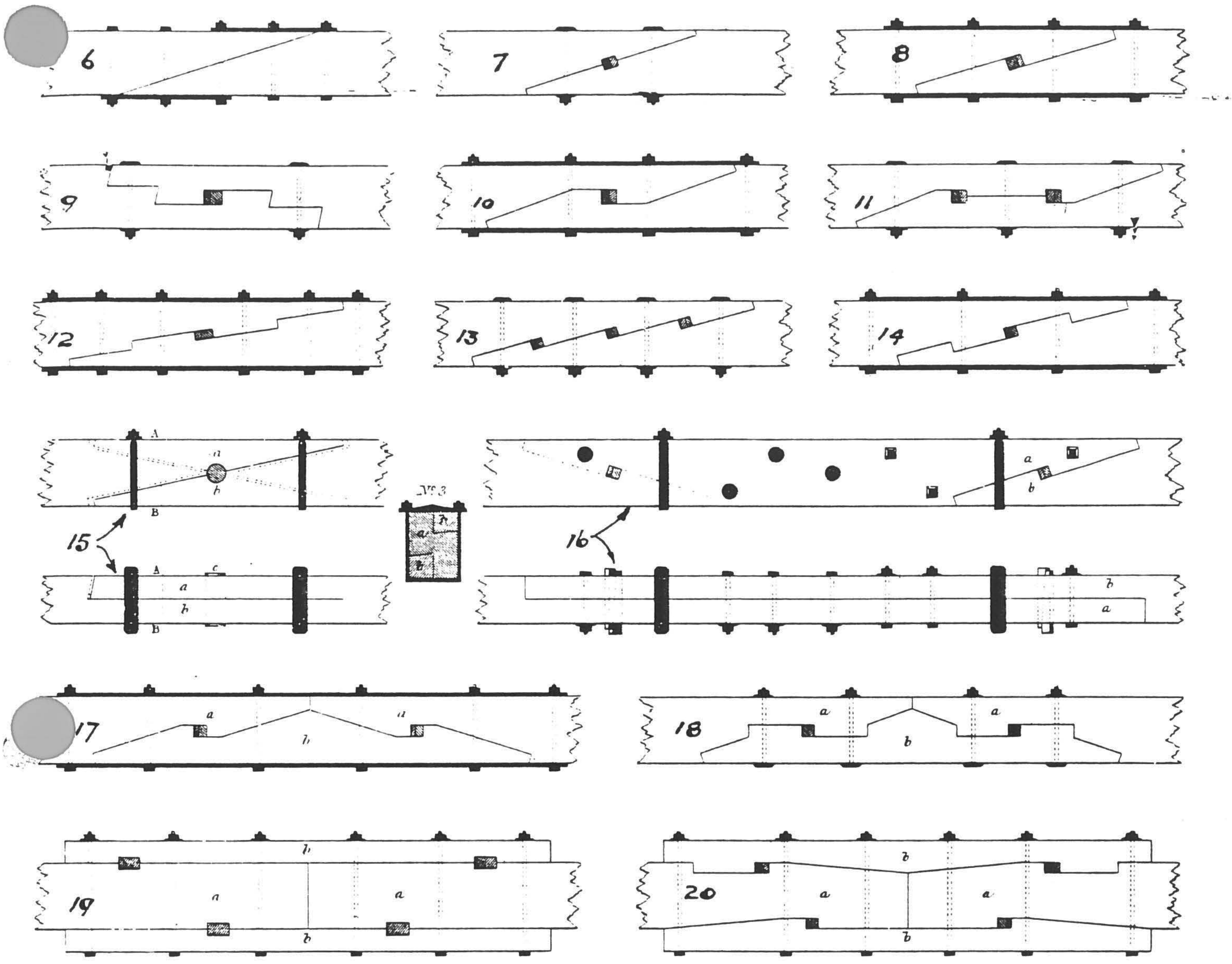


Plate VIIc

slipping is very greatly increased. This scarph is an improvement over Fig. 6.

Fig. 8 illustrates a scarph that is stronger than Fig. 7. Here the indentions are placed at ends and center and key is also used. With number of fastenings shown on illustrations the relative strength of the three scarphs is:

Fig. 7 is one and one-quarter times the strength of Fig. 6.

Fig. 8 is two and one-half times the strength of Fig. 6.

Figs. 9 to 14 show other, more complicated, methods of scarphing that can be used when maximum strength of scarph is desired.

Figs. 15 and 16 show two views of combined ver-[illegible]nd horizontal scarphs, and Figs. 17 and 18 illustrate [illegible]hods of lengthening beams by inserting a short piece between two longer pieces.

When a beam does not have to be same thickness throughout, the lengthening can be done by simply butting the pieces and lacing pieces of timber each side, bolting and keying the four pieces together.

Plate VIId Illustrations

Fig. 1 shows a plain fished joint.

Fig. 2 shows an indented fished joint.

Fig. 3 shows a keyed fished joint. *A, B* are keys.

This method of joining timbers is called *fishing*.

The timber used for the deck framing of a ship is seldom of sufficient length to permit the use of one-piece beams, so each beam and timber is generally composed of two or more pieces scarphed together.

Plate VIIe Illustrations

On Plate VIIe is shown methods of scarphing deck beams.

Figs. 21 to 23 show accepted methods of scarphing beams used for deck framing of vessels.

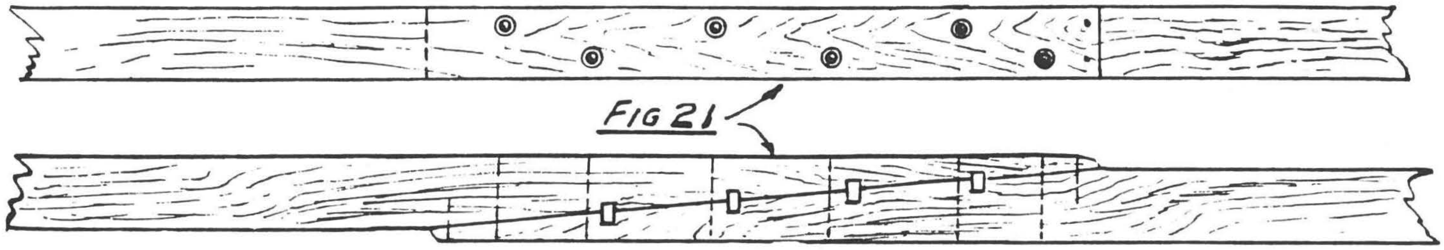


FIG 21

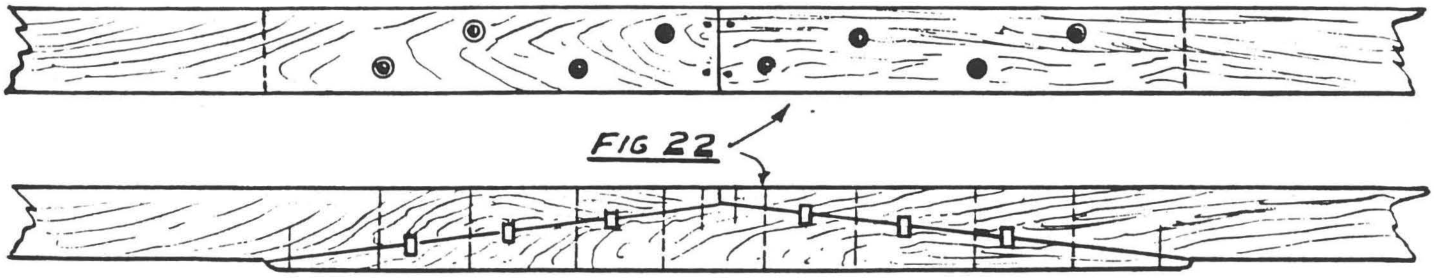


FIG 22

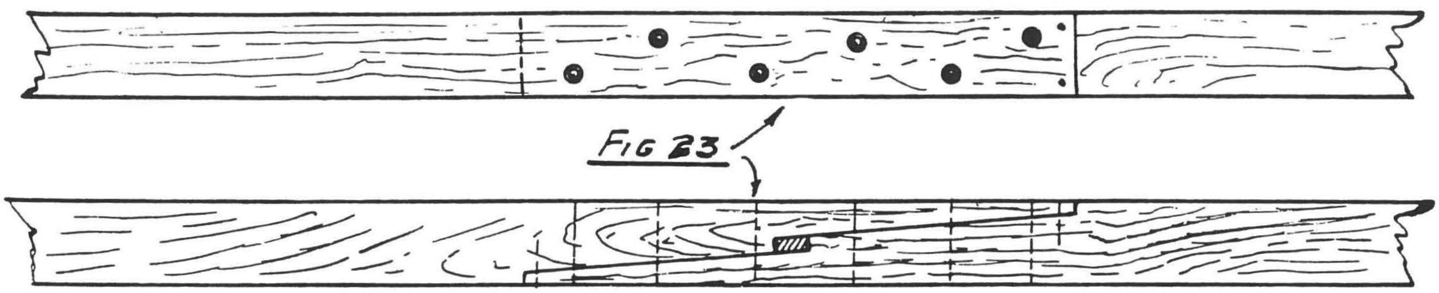


FIG 23

Plate VIIe

Fig. 21 illustrates how a two-piece beam is put together, the upper view being a side or moulded view and the lower one a view as seen from above. A scarph of this kind is usually made one-third the length of the whole beam.

In cases where it is necessary to make the beam out of three pieces, the scarph is made in the manner shown by Fig. 22. The length of scarph is usually about one-fourth the length of beam.

Fig. 23 shows an exceptionally strong method of scarphing beams. The keys in a scarph of this kind are of iron or steel and must be tapered and fitted snugly, and the lips of scarph must be cut square to the moulded edge of beam. The length of this kind of scarph need not be more than one-fifth or one-sixth length of beam.

7c. Dovetailing, Halving

Fig. 16 (Plate VIIf) shows two pieces of timber joined together at right angles by a dovetailed notch. As to dovetails in general, it is necessary to remark that they should never be depended upon for joints exposed to a strain, as a very small degree of shrinkage will allow the joint to draw considerably.

Figs. 17 and 18 (Plate VIIf) show modes of mortising wherein the tenon has one side dovetailed or notched, and the corresponding side of the mortise also dovetailed or notched. The mortise is made of sufficient width to admit the tenon, and the dovetailed or notched faces are brought in contact by driving home a wedge *c*. Of these, Fig. 18 is the best.

Fig. 19 (Plate VIIf) shows the halving of the timbers crossing each other. Fig. 20 shows a joint similar to those in Nos. 17 and 18, but where the one timber *b* is oblique to the other *a*.

Fig. 21 (Plate VIIf).—Nos. 1 and 2 show a mode of notching a horizontal beam into the side of an inclined one by a dovetailed joint. The general remark as to dovetailed joints applies with especial force to this example.

7d. An Explanation of Coaked Scarphs

The word coaked refers to a method of increasing strength of scarphs by preventing the joint from moving sideways or endways. A coak is a rectangular or round

ce of hard wood laid into the surface of the two pieces timber that are scarphed together in such a manner that one-half of depth of coak will be in each piece of timber. On Fig. 33 (page 49) is shown a properly coaked keel scarph, and you will note that by the addition of coaks the resistance to sliding has been greatly increased and the holding strength of bolts has also been increased. In the days when wooden ships were built in large numbers all the principal keel, stem, stern, keelsons and frame scarphs were coaked, but in these days coaking is seldom used, and in ignoring the advantages of coaking a scarph I believe the shipbuilders are making a serious error. Round coaks are used up to 3 inches in diameter and rectangular ones up to 3 inch × 6 inch.

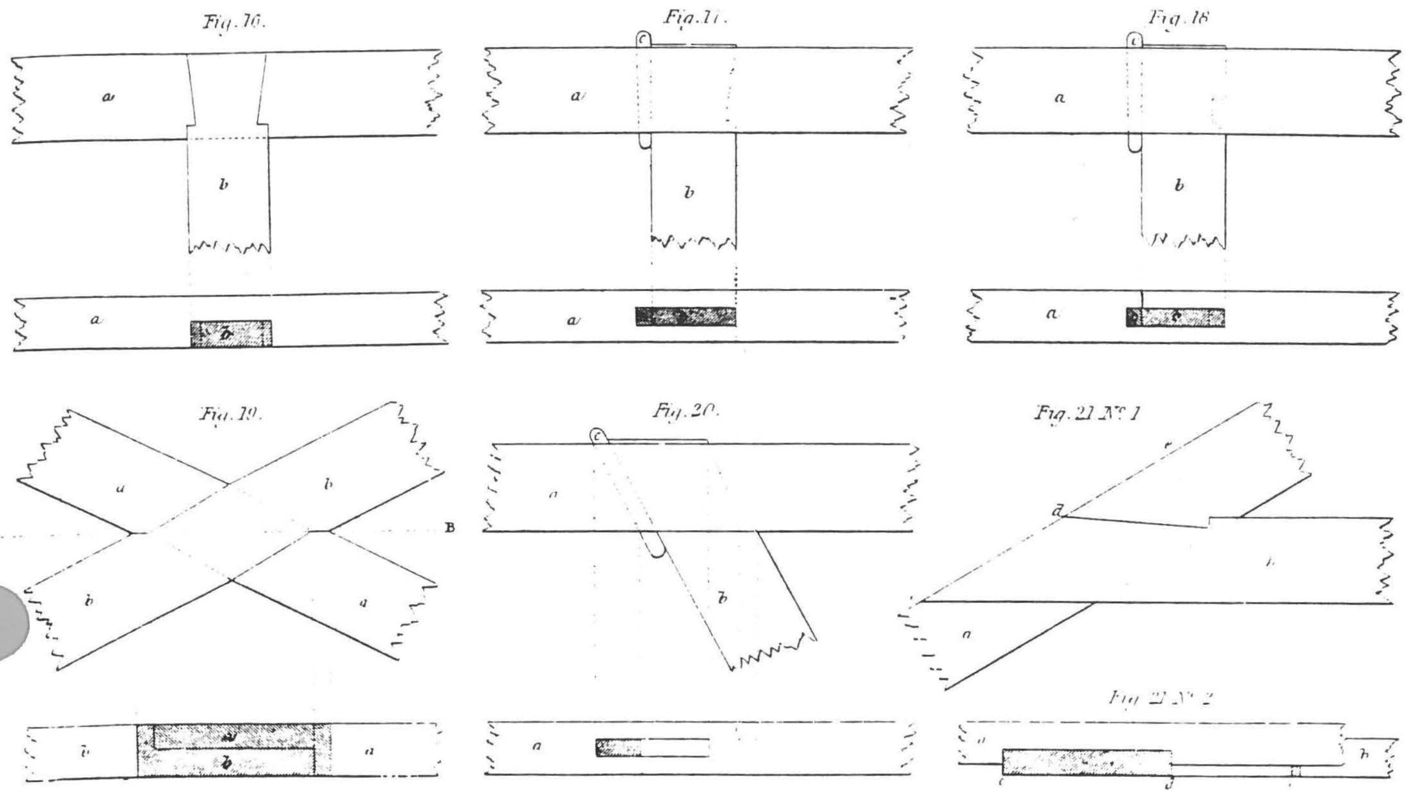


Plate VIIf

painter paints by machine. He sprays the mixture on the various surfaces by means of a compressed-air impulse; and with his hose and tank of paint he can get at any part of the vessel, and yet avoid many of the perils to which the brush operator is of necessity exposed.

It is fortunate for us, in our struggle to make the world a safe place in which to live, that the genius of our tool-makers has evolved these mechanical wonders by which so much can be done, and well done, by men who can be recruited from many ranks of our great army of labor. Otherwise, it would be quite out of the question to hope to produce with sufficient rapidity the great fleet of wooden craft that we need in the present national emergency.

Treenails

AN INTERESTING AND NOT UNIMPORTANT DETAIL OF THE REVIVED AMERICAN INDUSTRY OF WOODEN SHIP-CONSTRUCTION

By L. C. Everard

WHAT would be thought of a man who proposed to build his house with wooden nails? No doubt he would be put in the same category as a woman who would deliberately choose a thorn for sewing buttons on her husband's trousers when she could just as easily get a nice, bright steel needle. If the man were going to bump his house around the world, the wooden nails would seem even more absurd. Nevertheless, both ships of the past and ships of the present have been fastened together with huge wooden nails and sent out to brave the dangers of the sea and of battle.

It might be thought that the use of wood to hold ships together was an archaism preserved in this age of steel by the conservatism of old ship-builders who have handed down their art from generation to generation. It is not so, for iron and copper have competed with wood as ship fastenings from the days of Pericles, and probably longer, and neither metal nor wood has ever won a complete victory. They have seesawed back and forth from age to age in popularity.

If there had been many magnetic mountains in the sea like that described in the story of "Sinbad the Sailor," the wooden nail would have won in a walk, for no iron-fastened ship could have stayed together; but *Sinbad's* seems to have been the only natural marvel of its kind, and iron has gone into ship fastenings all through the ages. Long copper nails, taken from a galley which Caligula sailed on the Lake of Nemi in or about A.D. 40, may be seen in one of the museums of Rome. Nowadays a ship is likely to have both wood and iron fastenings.

Tremendous wooden nails, called treenails—"trunnels," in ship-builders' parlance—are still used to fasten together the planking, frames, and ceiling of wooden ships. The planking is the outer shell of the hull, the ceiling the inner, and the frames form the skeleton enclosed between inner and outer shells. The wooden nails have to be of considerable size to reach through all three thicknesses. In many instances they are as much as three feet long, and as large in diameter as one and one-half inches.

DRIVING AND WEDGING THE NAILS

A hole is bored with an auger through planking, frame, and ceiling, and the treenail is driven home in this with a wooden mallet. The men who do the work acquire a muscular development like a blacksmith's in the process; for the treenail is usually turned larger than the auger-hole, sometimes as much as one-sixteenth of an inch, and has to be whacked pretty hard to drive it in to the head.

Whittier, who well knew the work of the New England ship-builder, says in a familiar poem:

> Lay rib to rib and beam to beam,
> And drive the treenails free.

Unless the nail is of the best quality and of straight grain, it is likely to "broom," or split, under the hammering. There is danger of this even with the best material, and two ways have been suggested for minimizing the danger. The outer half of the hole is bored with one auger, and the inner half with an auger one-sixteenth of an inch smaller. The treenail is tapered one-sixteenth of an inch from head to point, or it is turned in two drifts, the half at the entering end just the size of the outer part of the auger-hole, and the half at the head one-sixteenth larger, each portion of the nail thus being one-sixteenth larger than the hole it must ultimately go into. A nail made in this form can be simply pushed in half the way and then hammered home.

After the nails are driven, the heads are sawed off even with the planking, a split is made in the middle of each head, and a wedge is inserted. Some ship-builders also wrap the treenails, near the head, in oakum before driving them home.

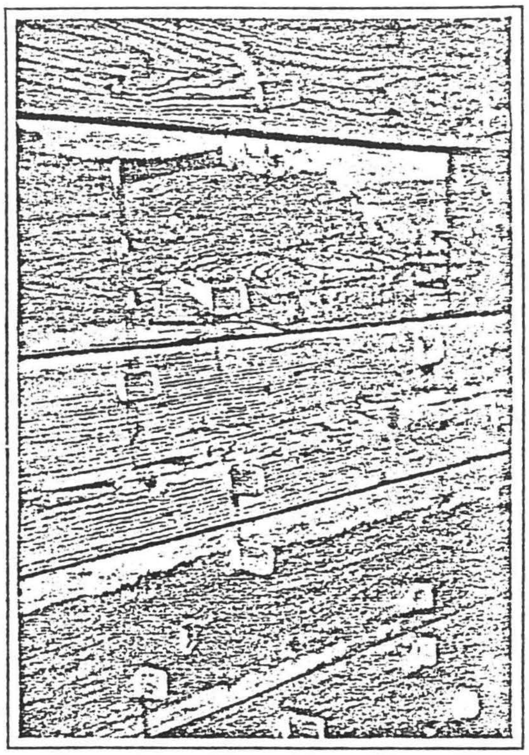
The wedges used nowadays are the full width of the nail, are driven in two inches, and are about one-fourth of an inch thick where they are cut off. Wedges are driven so as to spread the nail against the end grain of the planking, because if they were driven the other way the planking might be split.

There is something else besides the drift and the wedging of the head to hold the treenail tight. When the boat is put into the water, the nail swells. The auger-hole enlarges, too; but here a curious property of wood comes into play to clamp the treenail more firmly in its place. Wood shrinks and swells, with reduction or increase in its moisture content, very slightly lengthwise of the lumber, so that the difference in the auger-hole is very slight; but it shrinks or swells considerably the other way, so that the seasoned treenail becomes appreciably enlarged when it is soaked, and by pressing against the fibers of the planking increases immensely its holding power.

If you look at the side of a wooden ship, you will see no signs of these tremendous

DRIVING TREENAILS INTO THE TIMBERS OF A WOODEN SHIP, SHOWING NAILS PARTLY AND COMPLETELY DRIVEN—THE MAN IN THE BACKGROUND IS SAWING OFF THE HEADS FLUSH WITH THE PLANKING

wooden nails. It looks all smooth, and no doubt many a landsman supposes that the planking is nailed on just like the siding of a house. The reason for this smoothness is that after the wedging has all been done, the outside of the ship is carefully adzed, and the ends of the treenails are smoothed off even with the planking; then a coat of paint makes the ship look as much like one piece as a canoe.



WEDGING TREENAILS WITH IRON OR OAKEN WEDGES, WHICH ARE DRIVEN SO AS TO SPREAD THE NAIL LENGTHWISE AND AVOID SPLITTING THE PLANKING

The smoothing-out process is called "dubbing." It is a much greater success if the treenails are of black locust or Osage orange than if they are of live oak, which dulls the edge of the adz and is difficult to cut because of its extreme hardness and locky grain.

THE BEST WOOD FOR TREENAILS

In the palmy days of the British wooden ship-building industry, the treenails were made preferably of oak; but when the industry developed in America the Yankee ship-builder discovered that there was a strictly American wood much superior to the traditional oak—namely, black locust. The special qualities which make black locust the criterion for treenail stock are density, hardness, strength, and durability.

For many years black locust was always specified for treenails, and there was enough to supply the demand. For the tremendous ship-building program now being carried out, however, the immediately available supply is inadequate, and a number of other woods are being used, such as live-oak and Osage orange. The latter—which is also called bois-d'arc, meaning "wood of the ark," on account of its durability—is giving special satisfaction when properly manufactured. It has all the qualities desirable in treenails, and even if the color should run and dye the planking, the ship, like an artist in rouge, would hide the blemish under her paint.

At the beginning of the ship-building boom there was a tendency among those building ships for private owners to unscientific experiment with substitutes for locust. One ship-builder carried what may be called the "practical" method of experiment to an extreme. Without testing the qualities of the wood, he put American-grown eucalyptus treenails into a ship and sent her out. The unsuitability of the wood was demonstrated in such conclusive fashion that the practical experiment was a success to this extent—it got a definite answer; but those on the ship did not enjoy it, for they had to hurry into the nearest port. Eucalyptus wood is porous, so that water can get through it easily; and it had continued to shrink after being put into the ship, so that the whole fabric of the vessel became loosened. The eucalyptus nails were knocked out, black locust was put in, and all was well.

Australian-grown eucalyptus is better than American, but it is so difficult to get that it cannot be considered as a substitute for locust.

To establish a basis for comparing the different species of wood for various uses, thousands of tests have been made at the Forest Products Laboratory, conducted by the Forest Service at Madison, Wisconsin. These experiments have proved very useful in the search for woods suitable for treenails, as well as for other ship-building wood. The Forest Service has drawn up specifications for treenails which have been

adopted by the Emergency Fleet Corporation for all wooden ships now being built for the government.

The reason for seeking a substitute for black locust treenails will be apparent to the reader when he puts together these two facts—that builders of wooden craft are busy all along the coast from Maine to Texas, as well as on the Pacific, and that each ship requires from twenty thousand to fifty thousand nails. Furthermore, black locust is not a large tree, and does not grow in great stands, like pine and fir and oak, but is scattered, and has to be hunted down, a tree here and a tree there. Osage orange, the best substitute found so far, has a rather small and misshapen trunk, from which it is hard to get much material of the right size and quality.

No acute shortage of treenail stock has as yet been felt, but we have learned in the last few years that it pays to look ahead in such matters. Usually it is not simply a case of finding an article that will supply one demand; it is often advantageous to use an article perfectly adapted to one purpose for another for which it is no better suited, or to divert part of the supply to another use and find a substitute for use in the original way.

Wheat flour, for instance, may be the handiest and best material for making American bread, cake, and hot rolls; but a large proportion of it does more good in the war bread of our Allies. So it is with wood; and the Forest Service is not only seeking substitutes for species which are scarce, such as locust for treenails, but is striving to bring about the distribution of the wood supplies of all species to the uses and the industries where they will do the most good in the present emergency.

CITIES AND QUEENS AND KINGS

Cities and queens and kings
  Last but a day;
Time, like a wilful wind,
  Blows them away.

There was a queen of old,
  Fair as a flower;
Naught but her name remains
  Into this hour.

Was it the wind that blew
  Sadly and long.
Singing the name of her
  Like a lost song?

Kingdoms and empires vast,
  Tyrant and sword,
Yield to one king at last—
  One overlord.

Sargon, Semiramis,
  Babylon, Tyre—
O'er them the serpents hiss,
  The winds conspire.

Under their chariot-wheels
  They crushed the proud;
Time gives the desert dust
  To them for shroud.

Cities and queens and kings
  All go their way.
One with a wind that blew
  O'er yesterday!

Edna Valentine Trapnell

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Development of West Coast
steam schooner.

The Pacific Coast Steam Schooner

By David W. Dickie, Visitor[1]

Lumber was first carried down the Pacific Coast in small sailing schooners. The midship section of the *Beulah* (Fig. 1), length 146 feet, beam 35.5 feet, depth 10.9 feet, is typical of the 1882 period. The vessel is a three-masted topsail schooner popularly known as a tern.

Since it was possible to get poles for masts of any desired length, a later practice was to make the masts in one piece and the schooners took the general appearance of the *Commerce* (Fig. 2) along about 1900, length 184 feet, beam 38.6 feet, depth 13.6 feet. The topsail schooners like the *Inca* (1896), length 245.5 feet, beam 41.3 feet, depth 16.5 feet, and the *Geo. E. Billings* (1903), length 224 feet, beam 42.4 feet, depth 18.3 feet, reached the limit in size and accustomed the shipping people to the dimensions and proportions. The photograph (Fig. 3) of the *Vigilant* (1920), length 241.9 feet, beam 44.4 feet, depth 19 feet, shows one of them under sail loaded with lumber.

The first steam lumber vessels were typical sailing schooners with an engine and boiler near the after end. Later the engine house was made substantial and used as a samson post to centralize the deck load. At first the sails were complete, then curtailed and used for steadying the vessel and gradually were omitted as a means of propulsion as confidence in the steam plants grew until the vessels took the form of the *Willapa* (1908), length 178.5 feet, beam 40 feet, depth 13.3 feet, known as a single-ender and having the sailing vessel stern built up vertically to keep out the following sea (Fig. 4).

The term "single-ender" means that the lumber was carried on one end of the machinery as distinguished from the double-enders that came later and carried the lumber on each end of the machinery with the house and machinery about one-third of the vessel's length from the stern. The single-enders grew in size up to the *Port Angeles* (1916), length 223.2 feet, beam 42.3 feet, depth 15.8 feet, and the *Fred Baxter* (1917), length 213.3 feet, beam 42 feet, depth 16.1 feet, when the skill of the builders was no longer adequate to cope with the strength problem.

Previous to 1916 there were scattered instances of steam schooners built with the engines amidships, known as double-enders, but it was not realized by the builders that, if the lumber cargo

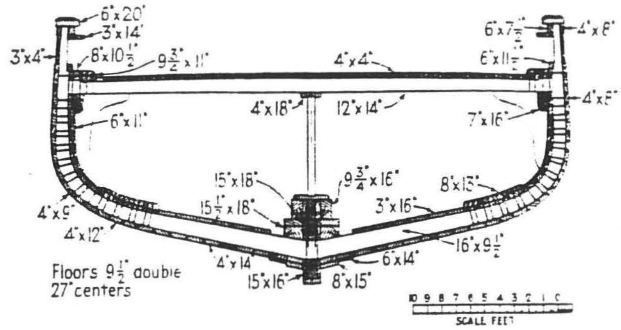

Fig. 1.—Midship Section of "Beulah," Typical Sailing Schooner of 1882

was omitted from the midship part of the boat, the vessel had to be made wider to get the same economy in carrying capacity.

From 1916 on to 1923 was the era of the double-ender represented by the *Edna Christensen* (Fig. 5). This vessel was designed to have 45 feet beam but the owner could not be convinced and his courage gave out at 44 feet. A little was gained by increasing the thickness of the planking on the topsides and carrying the increased thickness well down the sides.

The Pacific Coast steam schooner developed into a vessel with a high forecastle and poop to protect the ends of the lumber on deck.

The form of the vessel has to be:

(A) Fine below the light waterline to keep the propeller under water going north along the coast in the light condition.

(B) Full above the light waterline to make the vessel a good carrier.

[1] Engineer and Naval Architect, 112 Market Street, San Francisco, Cal.

(C) The displacement must be properly distributed fore and aft so the minimum of power is required to drive the vessel while at the same time permitting proper stowage at the ends of the hold.

Due to shallow water existing at some of the lumber ports in the early days, the draft was limited. Stability, when loaded, was the final governing factor. The steam schooners become tender when nearly loaded to the international load line. As loading proceeds, they become stiff when the wide elliptical stern comes down to the surface of the water, increasing the moment of inertia of the waterplane. In the final stages of loading the vessel becomes tender again, a condition that has to be maintained to avoid losing the deck load from excess rolling. The inclination of the vessel with the final sling loads hanging to the end of the boom indicates to the captain when to top off and lash the load.

As a background for the wooden steam schooner it is necessary to touch briefly on the difficulties that had to be overcome changing from the use of oak to Douglas fir in the construction of the ships. The available carpenters were men who deserted the sailing ships at San Francisco (often by

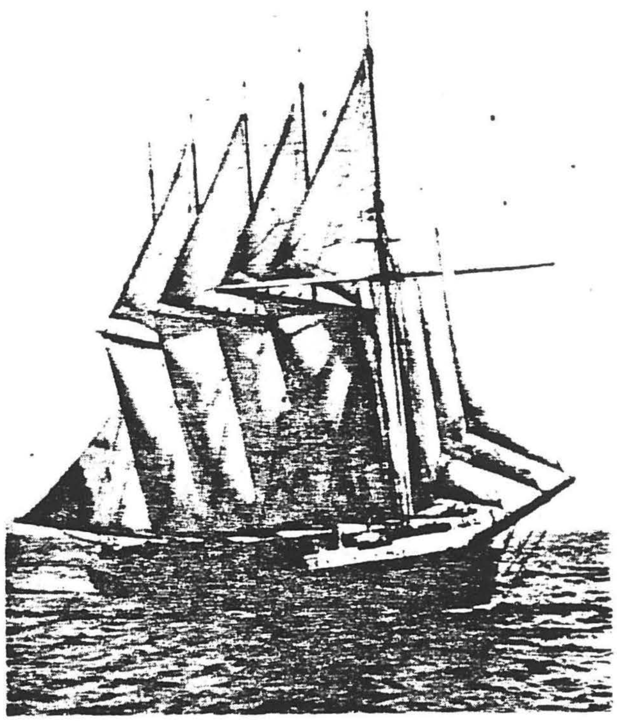

FIG. 3.—SAILING SCHOONER "VIGILANT"

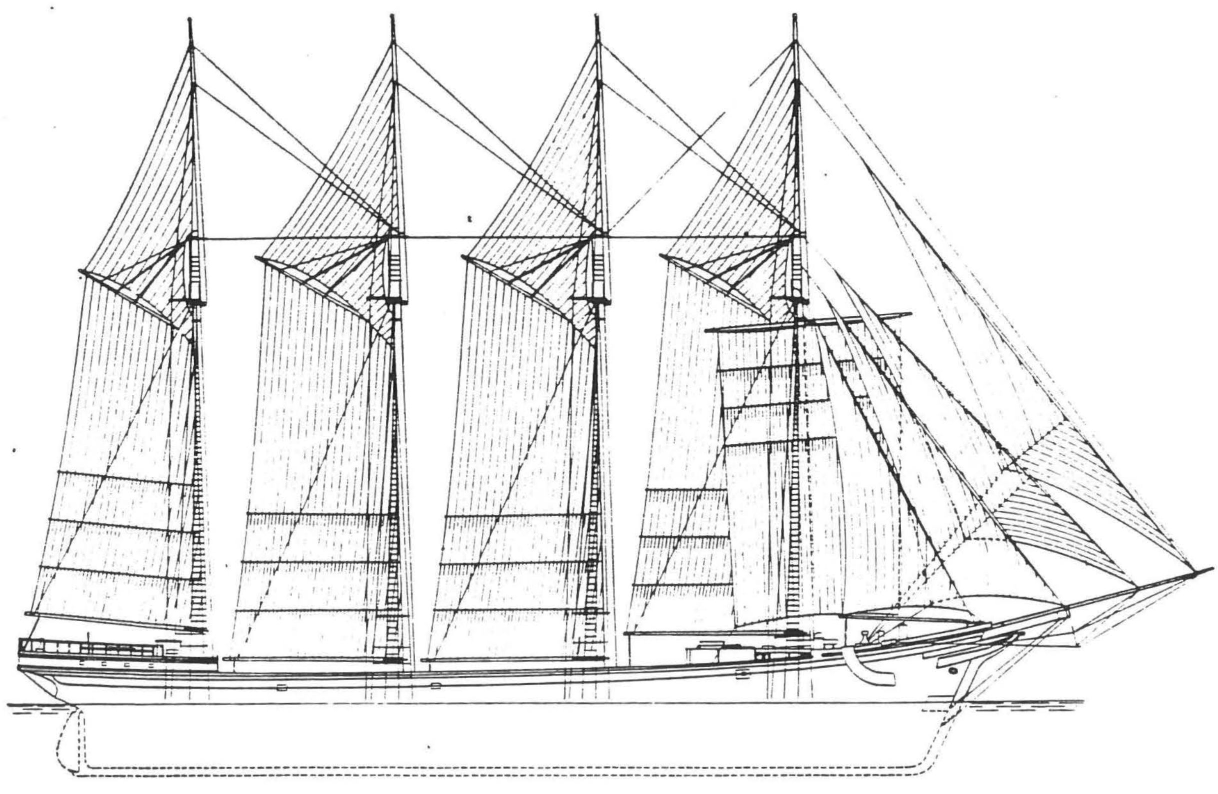

FIG. 2.—SAIL PLAN OF TOPSAIL SCHOONER "COMMERCE"

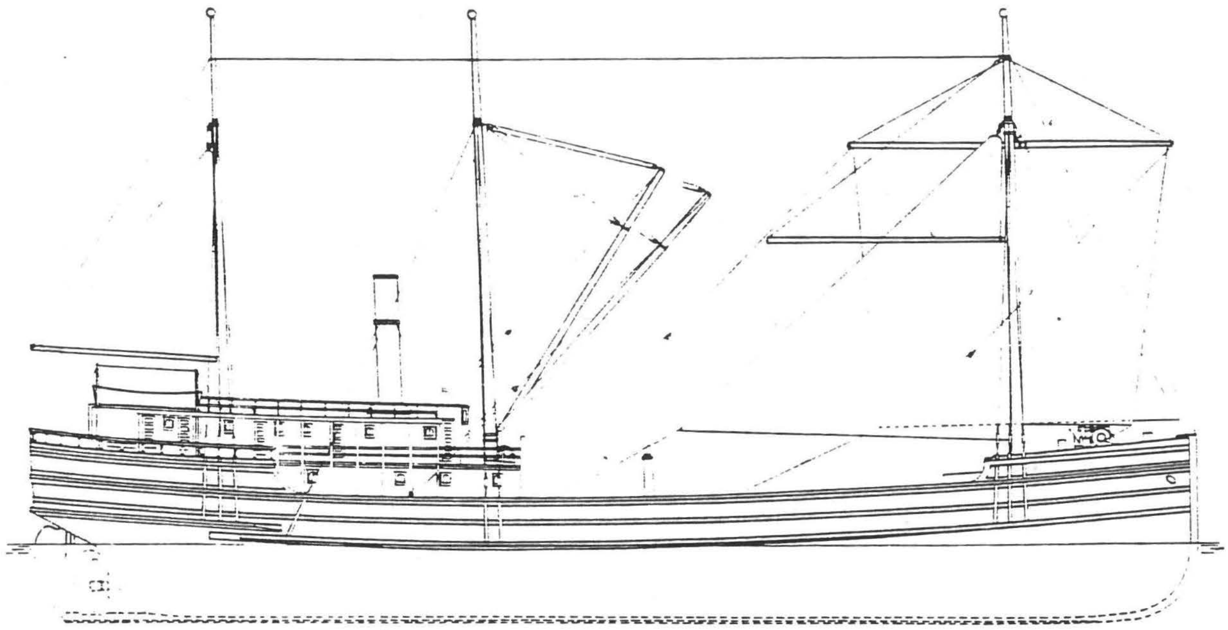

FIG. 4.—OUTBOARD PROFILE OF SINGLE ENDER STEAM LUMBER SCHOONER "WILLAPA"

request). They knew oak and pitch pine but required training to understand Douglas fir.

James Dickie, the author's father, made a study of the strength, fracturing and fastening of Douglas fir and found that it was a much better building material than any of the well-known woods on account of the availability of long lengths. However, certain changes in common practice had to be adhered to, such as:

(1) Generally speaking Douglas fir had to be fastened by putting the bolts through with a clinch ring on each end, rather than driving the bolt in and depending on the surface friction to hold it.

(2) When the vessel hogged or sagged, the fore and aft timbers slipped or sheared upon one another if there were insufficient fastenings or if the fastenings were not arranged so that a particu-

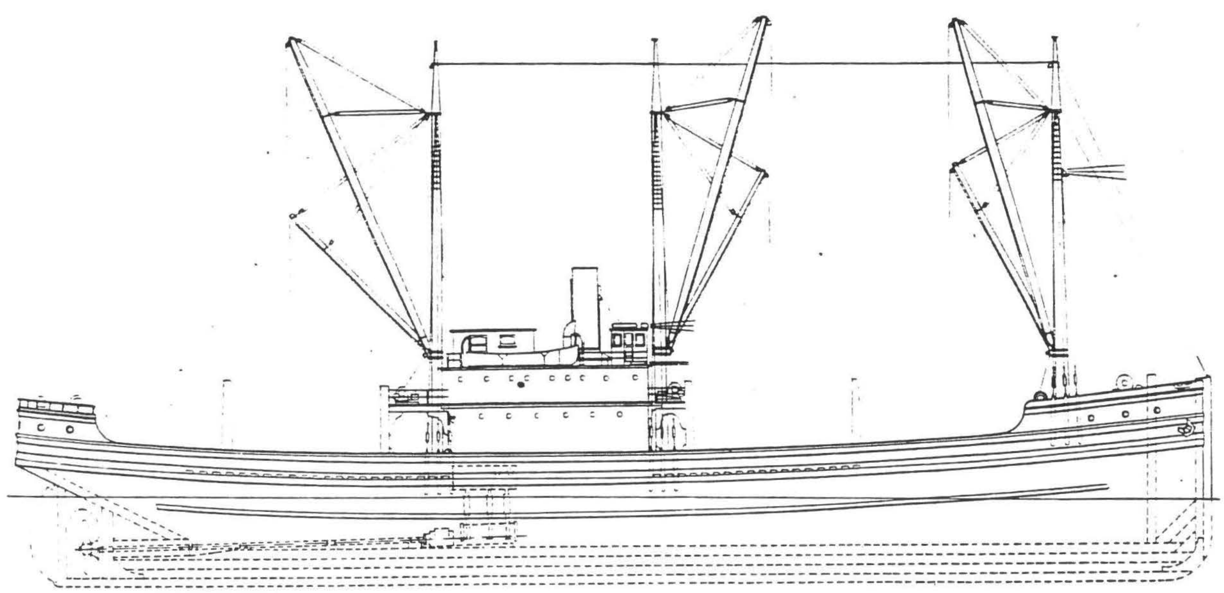

FIG. 5.—OUTBOARD PROFILE OF DOUBLE ENDER STEAM LUMBER SCHOONER "EDNA CHRISTENSEN"

lar bolt was in positive or negative shear simultaneously on both edges of the timber it was driven through.

(3) The fastenings had to be larger in diameter than for oak, so that the side of the hole would not crush when the timbers were strained to the point where they would slide upon one another. The long fir timbers without butts or scarphs concentrated the shearing forces at the fastenings.

(4) Cutting the timber oversize and seasoning improved the finished ship but entailed considerable waste to get rid of the surface checking.

After repeatedly refusing to consider the Pacific Coast wood vessels for classification or rating, Bureau Veritas finally instructed I. E. Thayer, their chief surveyor for the Pacific Coast, to contact James Dickie and submit a set of rules for construction. The rules of the United States Standard Register of Shipping and Bureau Veritas were altered and modified to form the present building practice on the Pacific Coast. After making the rules these men refused to permit the Bureau Veritas to adopt them because there was no long timber or root knees in France to serve as building material. With some modifications the American Bureau of Shipping rules for wood ships are very satisfactory.

Considerations of Stability

From a design point of view, stability can be reduced to the simple condition of having sufficient initial metacentric height. If we start from the waterline and calculate the distance the center of buoyancy is below it, then calculate the distance the metacenter is above the center of buoyancy and establish from experience the distance of the center of gravity below the metacenter, we will establish automatically the proper draft and height of deck load above the water, because only when a positive GM or metacenter above the center of gravity is present is the vessel stable.

The distance of the center of buoyancy below the waterline is given approximately by the simple formula

$$B \text{ to } WL = \frac{1}{3} \times \left[\frac{\text{draft}}{2} + \frac{\text{volume of displacement}}{\text{area of load water plane}}\right]$$

The block coefficient of the Pacific Coast steam schooner varies from 0.68 to 0.71 and the average of a group of them was found to be 0.6812.

The waterplane coefficient likewise averaged for the same group 0.8812.

Substituting, the above formula becomes

$$B \text{ to } WL =$$

$$\frac{1}{3} \times \left[\frac{\text{draft}}{2} + \frac{\text{length} \times \text{beam} \times \text{draft} \times 0.6812}{\text{length} \times \text{beam} \times 0.8812}\right]$$

$$B \text{ to } WL = \frac{1}{3} \times \left[\frac{\text{draft}}{2} + \frac{\text{draft} \times 0.6812}{0.8812}\right]$$

$$B \text{ to } WL = \frac{\text{draft}}{2.353} = 0.4248 \text{ draft}$$

Therefore, the center of buoyancy should be about 42 per cent of the draft below the waterline. It must be remembered that the keel extends about 16 inches below the outside form of the hull considered mathematically. So our formula becomes

$$B \text{ to } WL = 0.4248 \text{ (sight draft} - 1.33) = \text{feet below the waterline}$$

The foregoing formulas are based on hulls of certain forms. As a check, the average of the group gives

$$B \text{ to } WL = 0.4228 \text{ (sight draft} - 1.33) = \text{feet below the waterline}$$

Having located the center of buoyancy, the next step is to locate the metacenter.

The formula for this in terms of known quantities comes from the fact that the height of the metacenter above the center of buoyancy is equal to the moment of inertia of the waterplane divided by the volume below it. Let I = the moment of inertia of the waterplane.

$$I = nL B^3$$

where

L = length of the ship.
B = beam of the ship.
n = coefficient to take account of the shape of the bow and the stern.

The volume of the displacement is found as follows:

$$\text{Volume of displacement} = L\,B\,d\,m$$

where

d = the draft.
m = block coefficient.

Dividing, we have the height of the metacenter above the center of buoyancy

$$BM = \frac{n \times L \times B^3}{m \times d \times L \times B} = a\frac{B^2}{d}$$

where

$a = \frac{n}{m}$
B = beam of the ship.
d = draft.

The average value of a for the group = 0.0951.

$$\therefore BM = 0.0951\frac{B^2}{d}$$

The height of the deck load above the waterline of the vessel is almost the same as the draft of the ship with the outside depth of keel deducted. An average of the group gave 0.973 of the draft.

So the distance from the underside of the planking at the keel to the top of the deck load would be

$$\text{draft} \times 1.973 = D$$

The center of gravity of the ship and the lumber cargo is virtually at the center of the volume and the center of the volume below the top of the deck load is approximately as we have seen it for the center of buoyancy. Therefore the center of volume $= 0.4228 \times D$ below the top of the deck load.

An average of the group gave the center of weight of ship and cargo as 0.4916 below the top of the deck load. Substituting the value of D, we see that the center of weight below the top of the deck load would be

$$0.4916 \times 1.973 \times \text{draft} = 0.9699 \times \text{draft}$$

As the part of the deck load above the waterline $= 0.973 \times$ draft and the center of weight below the top of the deck load $= 0.9699 \times$ draft, the center of weight above the waterline $= 0.0031 \times$ draft, or for all practical purposes the center of weight is at the waterline.

Since the metacenter must be above the center of gravity to have the vessel stable, the BM or metacenter above the center of buoyancy must be greater than the sum of the center of buoyancy below the waterline and the center of gravity above the waterline.

The average metacentric height or GM for the steam schooners is 1.702 feet and it varies from 1.308 feet to 2.333 feet depending on the type of lumber cargo.

With a value for BM obtained from the sum of (center of buoyancy below the waterline) plus (center of gravity above the waterline) plus (metacenter above the center of gravity), we substitute in the formula

$$BM = 0.0951 \frac{B^2}{d}$$

and solve for draft

$$d = \frac{0.0951B^2}{BM}$$

There has been a great improvement in the lumber harbors since the formulas were made which has permitted the vessels to be built larger but all that was necessary was to substitute the draft (permissible at the harbors which the vessel was designed to serve) in the formula, solve for beam and all the other dimensions of the ship were determined automatically.

Hatches and Cargo Gear

The hatches on the steam schooners are made larger than usual, ranging in size from 12 feet by 24 feet to 24 feet by 30 feet. They have given some trouble at the corners and in some instances the deck has been made thicker and edge-fastened at the hatch corners. To facilitate stowage, some of the vessels have had a hatch fitted on each side of the centerline.

The original cargo gear was an invention of Captain Goodall of the Pacific Coast Steamship Company. It passed through several stages of

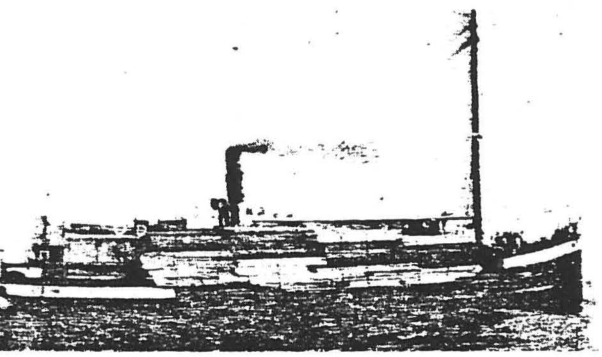

Fig. 6.—Single-Ended 1 Gear

development and finally standardized on a maximum lift of 5 tons. The average maximum sling load is about 3 tons.

Two booms are mounted on the mast with the falls led to two winches operated by one man having control of a winch in each hand. The winches are two-cylinder steam winches, either 8 inches by 12 inches, 10 inches by 10 inches or 10 inches by 12 inches, with a special steam valve that admits steam either hoisting or lowering. Electric winches were tried but proved too slow and had insufficient lifting capacity. The fall is usually ¾-inch diameter 6 strand 19 wires of the grade having the highest strength with maximum fatigue and wearing qualities.

A boom guy holds the peaks of the booms together with the purchase on the inboard side of one boom. An outside boom guy is fitted to each boom. The topping lift is a single wire with the purchase on the mast.

The design spread throughout the world with short booms but on the steam schooners the booms range in length from 60 to 75 feet to enable a sling load to be picked up well clear of the ship's side. Since then the world shipping cargo vessels have fitted king posts well away from the centerline of the ship to reduce the length of the booms.

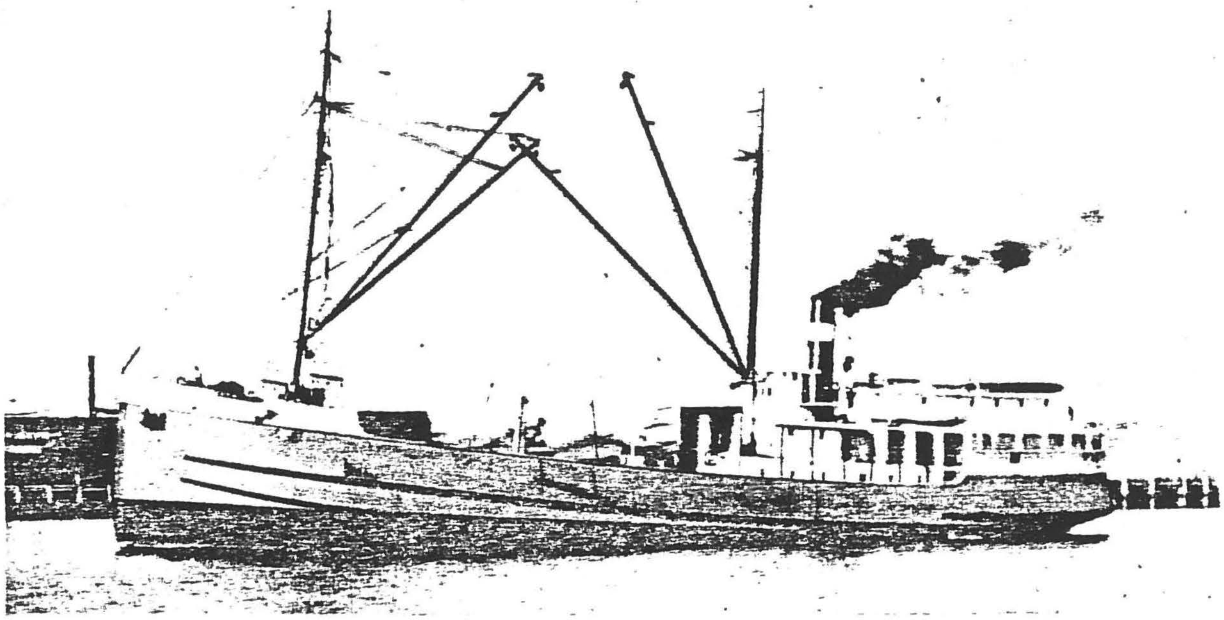

FIG. 7.—SINGLE-ENDED 2 GEARS

Practically all of the steam schooners are fitted with winch platforms. The winch platforms serve as samson posts to keep the lumber centralized on deck, move the winches up so the winch driver can see the sling load in transit and protect the winch driver against injury from a swinging sling load.

CARGO GEARS

The various designated types of masts and booms known as cargo gears are as follows:

Vessel	Cargo Gear
Single-ended 1 gear (Fig. 6)	One gear on a single mast at the forecastle

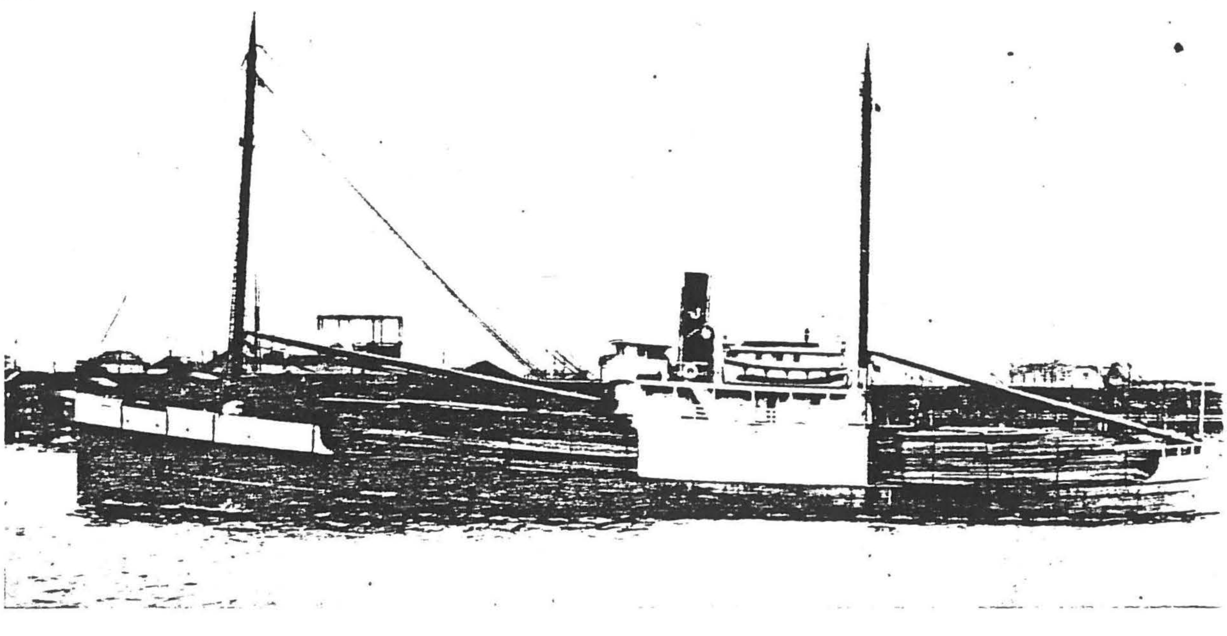

FIG. 8.—DOUBLE-ENDED 2 GEARS

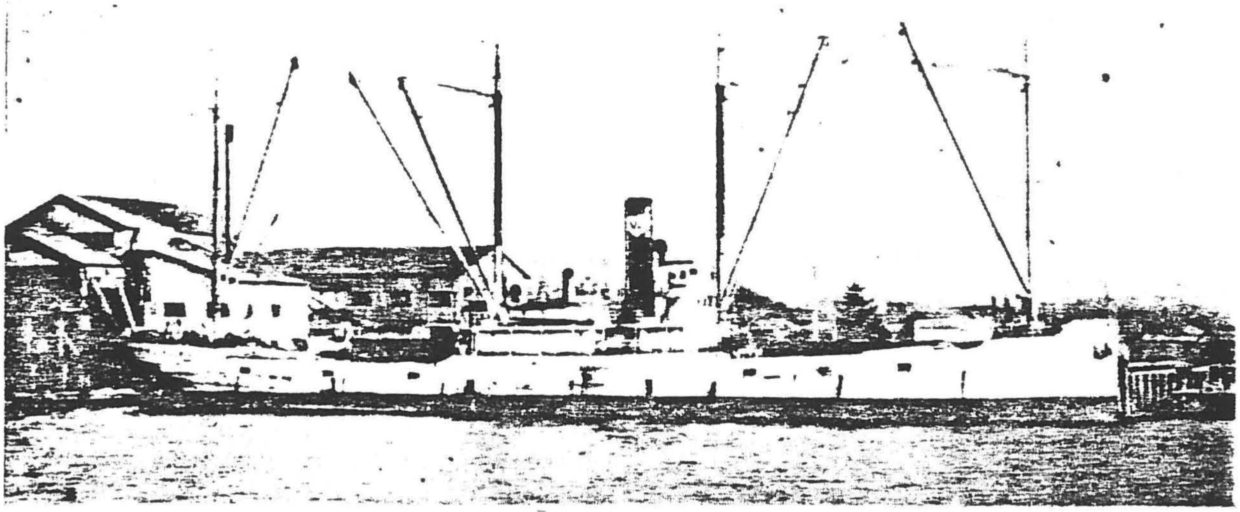

FIG. 9.—DOUBLE-ENDED 4 GEARS

Single-ended 2 gears (Fig. 7)	One gear at the forecastle. One gear at after end of the well forward of pilot house.
Double-ended 2 gears (Fig. 8)	One gear at the forecastle. One gear aft of the house.
Double-ended 3 gears	One gear at the forecastle. One gear at after end of the well forward of house. One gear aft of the house.
Double-ended 4 gears (Fig. 9)	One gear at the forecastle. One gear at after end of the well forward of pilot house. One gear aft of house. One gear at after end of after well forward of poop.

Some vessels were constructed with a short piece of deck or winch platform that extended from side to side of the vessel having lumber stowed under it. On this type the following gears are installed:

Vessel	Cargo Gear
Single-ended 3 gears (Fig. 10)	One winch platform midway between the forecastle and the house. Two gears on the winch platform. One gear forward of the house.

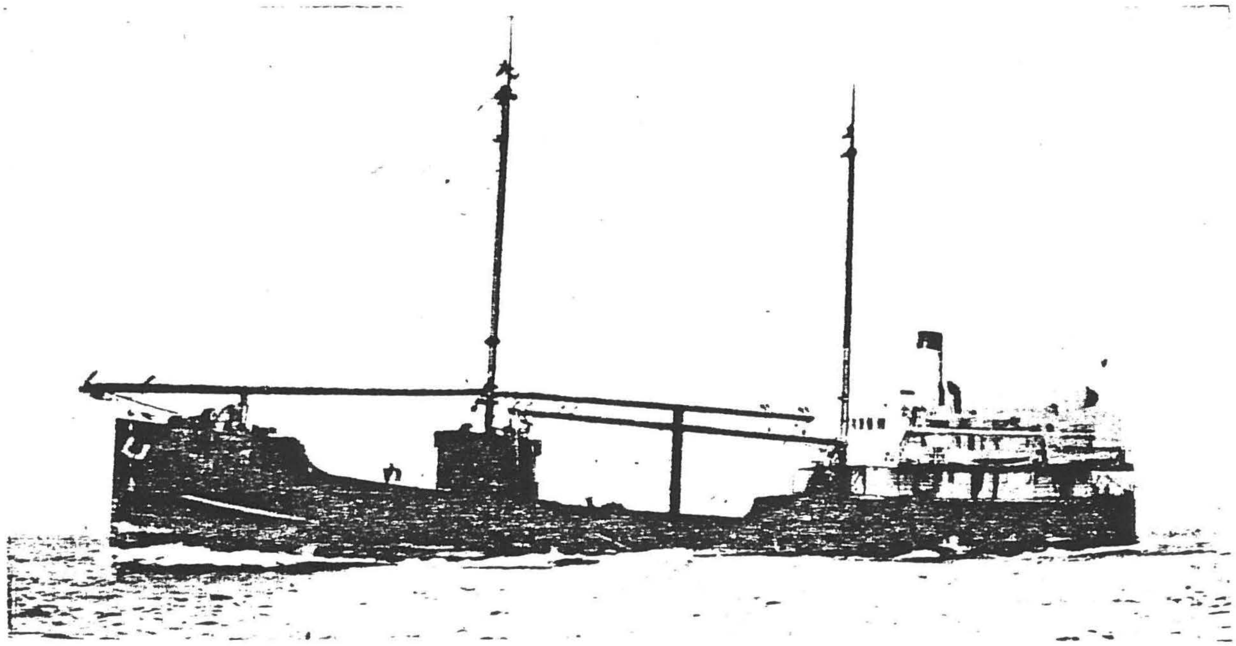

FIG. 10.—SINGLE-ENDED 3 GEARS

Vessel	Cargo Gear
Single-ended 4 gears	One winch platform midway between the forecastle and the house.
	One gear at the forecastle.
	Two gears on the winch platform.
	One gear forward of the house.
Single-ended 4 gears	Two winch platforms dividing the long well into thirds.
	Two gears on forward winch platform.
	Two gears on after winch platform.

Stowage

To facilitate stowing the lumber in the hold the ceiling dunnage on the bottom was carried along almost parallel to the deck above rising as it went forward. This caused the shape of the dunnage line to remain as far as possible parallel in width due to the widening of the vessel as the dunnage line rose forward.

In the sailing vessels such as the small schooners (*Beulah* type) the long lengths were stowed below deck through the bow and stern ports which were removable by unscrewing a heavy strongback inside of the vessel. These had to be calked every time they were closed. At a later date, as the vessels became larger, long hatches were designed to put the long timbers below.

The lumber has to be stowed on deck carefully to present a smooth surface to the sea and the forward ends are pushed under the after end of the forecastle. Many of the forecastles had to be raised to the height of the deck load to protect the ends of the lumber from the sea.

Later a set of ring bolts was put along the fore and aft hatch coaming girders on some of the vessels and each side of the deck load is stowed as a unit with its own chains leading from the deck at the side over the lumber to the hatch coaming. Between the wing stowages lumber is usually rough piled as it is released from the sling load and the top smoothed off with even stowage. Overall chains are then fitted embracing the two wings and the rough pile center. This obviates the difficult stowage over the hatches.

Steel Steam Schooners

After the great fire in San Francisco on April 18, 1906, the demand for lumber transport gave the operators a chance to accumulate a margin and some of them tried building steel steam schooners. The reasons they were not much of a success financially were:

(1) The shipbuilders knew nothing of the steam schooner problem and influenced the owners away from the "crazy" ideas they had learned from bitter experience with the wood vessels toward what might be termed a standard ship.

(2) The result was that the first vessels were too narrow and too deep to handle lumber economically. It was not until years later that the larger steel vessels carrying general cargo in the hold and lumber on deck were able to make the trade pay with the steel vessels. Compare the depth of the *Providencia* (1907), length 224.3 feet, beam 41.2 feet, depth 20.6 feet, with the *Noyo* (1913), length 224.4 feet, beam 41.0 feet, depth 16.6 feet.

In 1909 James Dickie and the author published a suggested steel steam schooner, length 287 feet, beam 45 feet, depth 22 feet. Even this vessel was too narrow, as later calculations showed, but it pointed the way. The special feature of the vessel was carrying the double bottom up the sides forming side tanks. The side tanks were used for fuel on the northbound trip when the vessel was light, which took the excess stability off the vessel in the light condition and delivered the excess fuel as cargo to the northern ports. When the *W. R. Chamberlin, Jr.* (1912) was built, the side tanks were combined along the centerline and the vessel was given the following dimensions: Length 295 feet, beam 44.5 feet, depth 21.5 feet. Due to lack of beam the vessel was tender and did not carry the height of deck load she was designed for.

Several vessels were built along about 1912 to 1914, such as the *John A. Hooper*, length 283.3 feet, beam 44 feet, depth 22.5 feet, but interest in the steel vessels died until after the World War I (1916 to 1918) when there were some vessels available from the United States Shipping Board fleet. Due to the low price, some of the Lake type, Small Point type and Large Point type were altered and fitted for the trade.

Since the establishment of the international load line the deck comes higher on the combined midship section of the ship and the lumber cargo which puts less of the cargo on deck, increases the cost of transporting the lumber and adds nothing to the safety of the ship. In fact, where the height of the lumber cargo above the deck is less than the height of the standard bridge deck it is not high enough to be properly held in place.

DISCUSSION

REAR ADMIRAL J. G. TAWRESEY, (CC), U.S.N., (RETIRED), *Council Member:* The author of this paper is a member of the family of shipbuilders that had so large a part in the development of shipbuilding on the Pacific Coast, at San Francisco. The three brothers, John W. Dickie, George W. Dickie and James Dickie, father of the author of this paper, had learned shipbuilding and marine engineering in the shipyards at Greenock, with the North British Railway, and in their father's yard at Tayport, Scotland.

The first to come from Aberdeen was George in 1869. He, curiously enough by study of a map, noted the large bay at San Francisco opening onto the great expanse of the Pacific Ocean. He visualized it as the place to build the ships to serve the commerce sure to develop.

On arrival he found shipbuilding at a low ebb. His first employment was in building the city gas works for lighting, the first such plant on the coast. Later he became the marine engineer for the Risdon Iron Works, then engaged in shipbuilding. In 1881 he became manager of the Union Iron Works when that company started to build ships for the new Navy.

The other brothers came to San Francisco about 1871. They started the building and repair of wooden vessels under the partnership name of Dickie Brothers. John continued the business at San Francisco and in Alameda until his death in 1927. James left the business to become superintendent in immediate charge of the Union Iron Works shipyard.

It was while building wooden ships that James Dickie devised the variations from previous practice, and the methods of framing and fastening, that made the softer woods of the coast practical for ship construction. That was a material contribution to the industry.

The Union Iron Works, while under the direction of the Dickie brothers, introduced steel shipbuilding and built many ships for the Navy and for the merchant marine. The more noted of the Navy ships were the *Oregon* and the *Olympia*, each of which had an important part in the Spanish-American War.

MR. C. HASTIE, *Member:* The Pacific Coast steam schooner, like the Douglas firs of which she is constructed and which as timber she usually carries as cargo, seems to belong in a category of her own.

Mr. Dickie's reference to her tall masts comprising staunch single units invites one to indulge in a little reminiscence and one is reminded of "Canoe and Saddle" by Theodore Winthrop, 1853.

". . . . Years of labor by artists the most unconscious of their skill had been given to modeling these columnar firs. Unlike the pillars of human architecture, chipped and chiseled in bustling, dusty quarries and hoisted to their site by sweat of brow and creak of pulley, these rose to fairest proportion by the life that was in them, and blossomed into foliated capitals three hundred feet overhead."

Douglas fir which occasionally we hear erroneously referred to as Oregon pine is one of the few great timber trees of the world. In the states of Washington and Oregon it grows best on fresh sandy loam reaching its greatest size on deep porous soils, well-drained, and is never found on swampy ground. Pound for pound it is the strongest resinous wood that has ever been tested and it is stated that the extra strength may be due in part to the spiral reinforcements found in the cells. In these and like qualifications it lends itself immeasurably in the construction of wooden ships.

The midship section of the medium-size conventional type of wooden steam schooner seems not unlike that of the *Beulah* as depicted in Fig. 1 although differing somewhat from that of nineteenth century crafts with their characteristic rounded form precipitated by perceptible deadrise and tumble home. Another feature would be the vessel's pronounced heavy garboard strakes in lieu of the gradual receding thicknesses of the bottom planking strakes protracted from keel to the first futtocks.

From 1916 forward, it would appear that decided changes in breadth and depth have taken place, with the lines approaching rectangular form, necessitating in some instances special reinforcing by way of steel strapping or the fitting of inner steel sheer strake plates connecting steel deck stringer plates or straps for concentrating the greatest strength away from the neutral axis, approximating the center of the load waterline plane.

In some types of vessels it is understood that, to help minimize obstruction in the holds, the tendency is to reduce the number of keelson timbers and increase the depth of floor or the size of bilge ceiling strakes and employ additional special edge bolting.

The considerations respecting stability will be

of interest to many but not too discerning to those who have often seen these vessels leaving port heavily laden and nattily trimmed with the after deck practically awash.

Mr. Dickie's remarks respecting the advent of the International load line regulations with due regard to the interest of the owners and the safety of their vessels are enlightening and potent.

Referring to metacentric heights, do the figures refer to revision consequent to subsequent freeboard assignment and larger ship dimensions, for it is known that a *GM* which may be ample for a fairly large vessel with good freeboard in a loaded condition may not suit a smaller boat with a correspondingly small freeboard?

The inference drawn from Mr. Dickie's remarks would apparently convey "that past experience in a particular field is the better arbiter" and applies also to business as well as to progress. In deep sea vessels of steel construction we have seen changes in dimension and witnessed the minimizing of freeboard with no dire effects.

Mr. Dickie: In reply to Mr. Hastie's reference to the stability of the Pacific Coast steam schooner it must be admitted that the whole problem was primarily a question of stability rather than freeboard. Strictly speaking, the lumber deck load was considered in the light of a semi-porous solid body and the freeboard was assumed to extend to the top of the deck load. The metacentric heights refer to the vessels before the advent of the international load line. In the case of the large steel cargo vessels carrying lumber on deck the international load line fixes the freeboard and the captain of the vessel regulates the stability by the type of loading which is adopted.

BENEATH THE WATERS OF TIME:
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MAXIMUM RESULTS FROM MINIMUM REMAINS

by

J. Richard Steffy

Few excavations yield hulls as well preserved as Kyrenia (Katsev and Katsev 1974) or Brown's Ferry (Albright 1977). Nautical archeologists must face the fact that many of them will never encounter anything more than sparsely preserved hull remains. This does not mean they cannot contribute scholarly results, however. How often does one read "nothing could be learned about the hull, since only a few planks survived" or, "there was not enough wood left to warrant investigation"? The tragedy in these statements lies not in the fact that these wrecks were poorly preserved, but that their remaining fragments were totally ignored. The value of excavated hull remains has nothing to do with the extent of survival; it is the amount of information gleaned from each fragment which is important.

It is true that Kyrenia has provided hundreds of pages of new information, and Brown's Ferry can be expected to produce similar results. But for every revelation those ships make possible, a dozen new questions arise. For instance, it was not known whether planking on shell-built ships could be repaired or replaced until such replacements were discovered on Kyrenia. But now we are puzzled by such questions as what special tools must have been used, why that particular procedure was followed, and so on. Nearly complete old and ancient hulls do not solve all the mysteries. They only provide us with enough intelligence to notice new ones. Ironically, if only one planking fragment survived from a 4th century B.C. hull and that fragment belonged to a slightly different replacement strake of the Kyrenia type (a possibility, since the replacements are usually much better preserved), all the questions raised by the Kyrenia repairs might be answered. That single fragment, then, would have been far too valuable to ignore. There are similar discoveries to be made on many poorly preserved hulls, if only we take the trouble to carefully scrutinize them.

I do not infer that Kyrenia and Brown's Ferry wrecks are not important ships. Their value will be realized for years to come, and the fact that their abundant evidence raises new questions is an asset indicative of a higher level of understanding. It is the relative value of the extent of hull survival that is wrong in the minds of so many archeologists. A shipwreck with ten tons of extant wood is not necessarily forty times more valuable than one with only a quarter ton. The big wreck may be less valuable. Value depends on many factors — period, condition of the wood, extent of the excavation, which hull areas and related artifacts survived, and expertise of the investigators to name a few. Unless one has an intact hull with enough expertise, funding, and diplomacy to preserve it in a castle or museum, the extent of hull survival has little to do with the value of the project. At the present time, a poorly preserved wreck dated to the 9th century B.C. would be potentially more important to historians than a well preserved 30-ton merchantman from the 4th century B.C.

The quality and quantity of information to be gleaned from fragmentary remains is usually limited only by the ingenuity of the observer. Magnifying lenses and oblique lights can be used to reveal obscure marks made by carpenter's tools and equipment handled by the crew. Such marks identify tool sizes and types, the effects of rigging on fittings, and even the habits and expertise of the shipwright. Laboratory tests confirm wood species, the composition of metals, and the types of caulking, pitches and paints. Bilge matter, aptly called "gunk," is especially interesting because it is likely to contain samples of everything dropped into the hold during the life of the ship. Seeds, sawdust, and sand seem to be the most common bilge items, although our finds have ranged from coins to rats.

If the ship is not intended to be excavated, such features are more difficult to determine. But dimensions can be taken anywhere, even at zero visibility, and dimensions are the most important data of all. Thicknesses and widths of all timbers are important. So is their frequency, especially frame and wale spacing. The sizes and frequency of fasteners, the curvature of the hull — the list of items to examine and record goes on and on.

At what minimum level of preservation does one ignore the study of the hull? Even a single fragment may be valuable; its importance should certainly be investigated by the excavator. Two sparsely preserved wrecks, whose hull remains were recorded, exhibited different, but important results. One of these was the Cape Gelidonya wreck (Bass 1967), a Bronze Age trader excavated by Dr. George F. Bass in 1960. There were only five distinguishable fragments scattered among dunnage and ballast stones, yet 15 important

dimensions were recorded. With today's improved techniques, that list might have been doubled. If a half dozen new Bronze Age shipwrecks are recorded in the future, each contributing only 15 new facts, we will be well on our way to understanding Bronze Age ship construction.

The Porticello wreck (Eiseman 1975) was little better preserved, but its few fragmentary remains were also documented. Again, there were only a ~~dozen or so vital~~ statistics concerning this 5th century B.C. vessel. By comparing these fragments with the slightly later Kyrenia ship, however, we were able to record pages of additional information regarding hull construction.

In both cases, hull survival was so sparse that ship finds might have been ignored, yet the recorded information proved helpful. Had those fragments been avoided, we would be lacking that much knowledge concerning two important maritime periods. Just as great cathedrals were built with nickel and dime contributions, so will small contributions from nautical archeology play an important role in the total description of man's past.

Limited budgets are no excuse for ignoring wood. Substantial knowledge of a particular vessel can be gained by making simple sketches and a few important measurements; even if there is no time or money to permit triangulation or photography, approximate provenience can be readily noted. Nor is the argument that it is morally wrong to remove hull remains a valid excuse for ignoring the ship completely. Ships do not have to be removed or disturbed to accomplish good hull interpretation. If it were morally right to expose the hull and excavate artifacts, however, then it is proper and necessary to record that exposed hull before backfilling. Archeologists can no longer ethically decide which part of a shipwreck is most important, regardless of their personal interests. Every part of a wreck is equally important because there are many disciplines interested in the results of an excavation.

In a sense, a sunken ship is an artifact — it is sometimes the most important artifact. Unlike representations, translations, and documents, it is primary evidence in three-dimensional form. Ships and pieces of ships bear tool marks, graffiti, and decorations. Anchors, fittings, and fasteners spell out the metallurgy of the period. Wood types, and their application, tell of forestry and the timber trade. Construction techniques indicate expertise, design reveals technology, and scantling determines hull size where much of the hull may be missing. Any old or ancient object so revealing, be it artifact, hull, or hull fragment, is far too important to be ignored.

By all means excavate cargoes and artifacts, but please don't stomp on the wood in doing so.

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UNDERWATER ARCHAEOLOGY:

THE PROCEEDINGS OF THE ELEVENTH CONFERENCE ON UNDERWATER ARCHAEOLOGY

EDITED BY
CALVIN R. CUMMINGS

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THE TECHNICAL IMPORTANCE OF SHIPWRECK ARCHAEOLOGY

WILLIAM A. BAKER

"Is this vessel important?" is a question often received in connection with underwater ship finds. An underwater ship find may be of importance to a number of persons depending on their particular interests. A technical historian might want to study the vessel's form and construction; the archaeologist will seek to retrieve artifacts pertaining to the cargo, passengers, if any, and crew; a salvager would be looking for items that could easily be disposed of to collectors and scrap dealers; while an oil company might simply consider the find an obstruction to a proposed pipe line. The current questions concerning the importance of underwater ship finds may stem from the recent studies of the cultural resources of the continental shelf.

Underwater ship finds are popularly called shipwrecks but the term wreck implies destruction. A real shipwreck, a vessel driven on shore by a storm, more often than not is broken up and its contents scattered. A study of the remains of such a vessel and its contents is rarely fruitful; items retrieved may be of interest only as curiosities from the sea. There are, of course, exceptions to this and many valuable objects have been brought up from the sea bottom but their context is lost forever.

Vessels have been and occasionally still are overwhelmed by storms at sea and founder relatively intact; the same condition applies to victims of collisions. The new schooner *John F. Leavitt*, battered by a 3-day North Atlantic gale on her maiden passage south with cargo, went down about 150 miles southeast of Cape Cod on December 27, 1979. After foundering, much then depended on what happened on the sea bottom. In the case of a wooden vessel, it was a race between gribbles, ship-worms, and other destructive forces, and a protective covering of mud and sand. Iron and steel vessels have long underwater lives but they, too, ultimately will disintegrate. It is such foundered vessels, however, that offer the best opportunities to archaeologists and technical historians.

In the majority of cases, what remains on the sea bottom after a century or more of exposure is a collection of the heavier objects that were in the foundered vessel - anchors, chains, guns, coins, ballast, etc. - better examples of which may already be displayed in museums. Perhaps buried in the mud or sand, there may also be the bottom structure of the vessel looking like the backbone and ribs of a fish lying on a beach.

Identification by name of a chance ship find in this condition is nearly impossible. The find then assumes an importance in the categories outlined earlier for what it is, not because of name and associations with events which may only have produced a certain notoriety.

It also approaches the impossible even to determine the type of vessel, for in spite of what has been printed in nautical dictionaries, nautical terminology has never been static. Sailing vessels whose type names were based on rig are impossible to identify from bottom structure as are those whose names were derived from use. An example of the former might be a ketch, and of the latter, a pinnace.

Clues concerning a vessel's origin at least may sometimes be obtained from casting marks on guns; these can provide information as to date and place of manufacture. Guns, however, often were transferred from ship to ship, particularly in the cases of armed merchant vessels, and sometimes from country to country. Anchors are even more difficult to identify but the shanks of Spanish anchors were said to have been longer and of smaller diameter than for comparable weight anchors from other nations. The nationality of an an-

chor, however, is not always that of the vessel, for anchors could be salvaged from wrecks or the bottom of a harbor and sold to any ship that needed them.

In spite of the lack of identification - there may be enough small artifacts to allow the guessing of a date and nationality - some ship finds are well enough preserved that a technical historian may be able to demonstrate the differences between how a ship should have been built based on the evidence of models, scantling tables, and text books, and how it actually was put together. Every vessel is likely to show minor peculiarities that are its builder's practices. On the other hand, some peculiarities may be chance indications of prudence, for in the days when timber and plank were hewn and sawn by hand a piece of wood was not discarded simply because it was not a mirror duplicate of the one used on the other side of the vessel. The concept of symmetry in shipbuilding apparently came relatively late in some areas.

It may be that the lowest level of importance in underwater work - and one wonders just what may be the ultimate solution - involves the planned or attempted recovery of material from vessels stripped and deliberately scuttled. Dry archaeologists find things of interest in abandoned land sites; the same may prove true underwater.

Except as obstructions and scrap value, a large percentage of the relatively modern unidentified ship finds are of no real importance to anyone. When in service the vessels were ordinary carriers transporting prosaic cargoes; their only importance lies in what may be obtained for objects brought to the surface and sold to collectors. In these days of energy problems, however, a cargo of coal might be an attractive discovery and there may be retrievable oil in the tanks of sunken oil carriers.

The point to emphasize here is the importance of the shape, structure, and fittings of a ship versus its contents which pertain to its use, how the crew and passengers lived, and what cargoes were carried. We have relatively few examples of ships of the past, but there are museums full of the common artifacts of earlier eras. There is no point in retrieving and conserving items from the sea bottom when equal or better examples already exist.

The technically important ship finds in general are those that can be dated before say 1650, about the time that printed books on ships and shipbuilding began appearing in greater numbers. Recent years have seen a number of such finds, but detailed reports have not always followed the preliminary accounts; most of these finds are well known to underwater archaeologists.

The so-called Kyrenia ship of the late 4th century B.C. found off the north coast of Cyprus is important because of its shape and construction details. In it we have a type of construction that even in its day was old - a shell of smooth edge-fastened planking to which framing was added. The edge fastenings were the familiar mortise and tenon. Apparently an ordinary cargo carrier, it is likely that the Kyrenia ship was one of a kind, a vessel of a given size built to suite a merchant's requirements.

The Punic vessel now being assembled at Marsala, Sicily, considered to be a warship sunk in a battle in 241 B.C. has details similar to the Kyrenia ship; it is considered to have been relatively new when sunk. Its importance, however, may be more in the line of implication than in actual features.

It is known that in 261 B.C. the Romans produced 100 quinquiremes and 20 lighter triremes in 60 days "from the tree". The vessel at Marsala shows from markings along the keel and on the planking that such feats of construction had to be accomplished by standardization. We can only conjecture at this time how such standardization was achieved - by models, by plans of some sort, or by taking an existing vessel apart and using each piece as a pattern. The latter apparently was the Roman procedure for the 100 quinquiremes which were copies of a captured Punic warship. Patterns have been used in modern times in small boat construction which, for example, enabled four men to complete a 28 foot whaleboat in 28 hours.

The Serce Liman (Sparrow Harbor) vessel found off the coast of Turkey and excavated primarily because of the possibility of its being an evolutionary step in ship construction has been dated about 11th century A.D. It is - was might be better, for relatively little of the hull remains - a small flat-bottomed double-ender about 52 feet long with a breadth of between 17 and 20 feet. At present it is the earliest known vessel in which the planking was fastened to a pre-erected skeleton frame. A 1st century B.C. Roman vessel now being excavated off the southern coast of France seems to be an intermediate stage between shell and skeletal construction.

The five Viking-age vessels circa 1000 A.D. excavated from Denmark's Roskilde Fjord in the early 1960's carried a bit further in time the northern European type of shell building first seen in the Nydam find of about 300 A.D. and found fully developed in the 9th century vessels from Oseberg and Gokstad in Norway. This type of building used the lapped edge-fastened planking commonly called clinker. One of the five vessels was the first knorr or cargo vessel to be found; all earlier Viking-age ships had been warships or what might be called "yacht" versions of them, vessels not suitable for a voyage to Iceland. Some surprisingly advanced engineering details were found in these vessels - what might be called webbed angle clips carved from solid chunks of wood, and floor timbers that were thin where they were deep across the keel but which gradually thickened as they became shallower over the planking.

For years maritime researchers argued about the features of two strange looking types of vessels portrayed on the seals of various medieval towns, in manuscripts, and in church paintings, the cog and the hulk. During dredging operations in 1962 in the harbor of Bremen, West Germany, there was the important find of a cog which ended most of the speculations about that type. This cog appears to have been sunk before completion, and it is now believed that it was swept by a flood, tide or otherwise, from the building yard into the river Weser. Having been sunk in a river and probably fairly quickly covered by silt, the Bremen cog, now dated about 1380 A.D., is very well preserved. With a length of about 77 feet and a breadth of a bit over 24 feet, it is estimated to have been able to carry about 125 tons of cargo.

The Bremen cog's construction is unlike any previous type and its ancestry is still questionable. Its bottom, nearly flat amidships, is formed of three flush-seamed non-edge-fastened planks on each side of a shallow keel, the type of planking usually called "carvel" because, as the Portuguese put it, caravels were usually built that way. The remainder of the cog's planking is standard clinker. Several heavy tie beams that support the cog's single deck protrude through the side planking; these beam ends are the characteristic lumps along the sides of the various portrayals of the type. The Bremen cog has provided an explanation for a 1943 find in Denmark's Kolding Fjord, others in the new polders created from the Zuider Zee, and a vessel found in 1976 near Elsinore north of Copenhagen.

The *Mary Rose*, sunk off Portsmouth, England, in the 16th century, will, when and if raised, fill a considerable gap in maritime knowledge. It accidentally capsized in the Solent on July 19, 1545, while going into action against the French. Immediate attempts to right the *Mary Rose* and lift it by stages into shallow water failed but various attempts to recover some of its armament continued until 1549. Its masts broke off, it settled into the mud, and was forgotten.

Built in 1509 - 10 as a 500 to 600 ton carrack for the fleet of Henry VIII, the *Mary Rose* was rebuilt as a 700 tonner in 1536. The method of calculating these tonnages is not known. This carrack is important because it was the first English warship to carry complete batteries of siege artillery as main armament on complete gun decks. Rediscovered in the 1830's by the first helmeted divers, artifacts were retrieved from the wreck in 1836 and 1840. Forgotten again until the 1960's, a concerted effort relocated the wreck in 1965, and since then a considerable amount of survey and excavation work has been accomplished.

By contrast, near the *Mary Rose* are the remains of two vessels that are relatively uninteresting as ships, the *Royal George* which capsized at anchor in 1782 and the *Boyne* which sank in 1795; both were line-of-battle ships from a reasonably well-known period. Nelson's *Victory* that is preserved at Portsmouth was built in 1765.

Interest in old ships has changed considerably since the 1920's when one, said to have been as well preserved as the Swedish royal ship *Wasa*, was blown up in Stockholm harbor to provide wood for the manufacture of furniture. No one can deny the importance of the *Wasa* which capsized on its first trial under sail in 1628; it is important from many points of view, but primarily because it is an almost complete hull of 1628. It is far from the situation where the probable appearance of a ship is deduced from a few bottom planks and a rib or two. There are some practical limits to the shapes of wooden ships.

It is unlikely that anything as important as the Kyrenia ship, the Breman cog, or the *Wasa* ever will be found in the waters of the United States, but there may still be a few surprises lurking here and there. The vessel raised on August 28, 1976, from the Black River at Brown's Ferry, South Carolina, is one such surprise. A double-ended round-bilged, flat-bottomed craft without a keel and built of local species of timber, it is about 50 feet long with a breadth of 14 feet. Dated about 1740, it is unlike anything previously known in the United States, but museum curators in the Low Countries find little unusual about her. The vessel's European ancestry may be explained by the fact that colonists of Germanic origin moved from Pennsylvania to South Carolina early in the 18th century. Although found in a fresh water river with a cargo of brick on board, the Brown's Ferry vessel had seen salt water service, for its planking shows teredo damage and among the artifacts on board was a nearly complete Davis quadrant.

Still being excavated in the harbor of Stockton, Maine, are the remains of an American privateer identified as the brigantine *Defence* that was part of the disastrous colonial expedition in August 1779 against the British in fortified Castine. When a British fleet appeared at the entrance of Penobscot Bay about 40 colonial vessels fled up the river where they were scuttled or run aground and burned. The *Defence* was in the latter category; its stern was blown off when the fire reached its magazine. It sank and settled into the mud where it is today.

Although from a period for which standard shipbuilding techniques are fairly well known, the *Defence* is of interest because its structural details indicate hurried construction with perhaps the feeling that it was expendable. Many of its frames and a large breasthook still have bark on them, and its structure is considerably lighter than that of what is thought to be the wreck of another privateer of the same period. Because of its size and shape, the *Defence* could have had but limited post-war commercial use.

Other examples could be cited but the foregoing will suffice. Without ships there would be no artifacts pertaining to crews, passengers, and cargo. In conclusion, let this be a plea to concentrate on the excavation of underwater ship finds that offer some promise of information about the ships themselves.

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The excavation and identification of the ex-American whaler *Day Dawn*

Mike McCarthy
Maritime Archaeological Association of Western Australia

Introduction

The Maritime Archaeological Association of Western Australia is a volunteer body, formed in 1974, by a group of divers and historians interested in the vessels wrecked on the coast of Western Australia (Robinson, 1977). It works in close co-operation with the Maritime Archaeology Department of the Western Australian Museum, and it is through the Association that interested members of the general public are able to become involved in the field of maritime archaeology (Green & Henderson, 1977).

Over a number of seasons the Association has developed a core of members, with a wide range of expertise and field experience. This has come essentially from working with the Maritime Archaeology Department on the sites of the VOC ships *Batavia* (Green, 1975) and *Zeewijk* (Ingelman-Sundberg, 1977) and the ex-slaver *James Matthews* (Henderson, 1976). This semi-professional experience has been augmented by work on other smaller projects and archival research instigated and directed by leading members of the Association.

In early 1976, a wreck was uncovered by a dredger working on the site of *HMAS Stirling*, a new naval facility being built in Careening Bay near Fremantle, Western Australia (Fig. 1). This was the second such wreck to be found in this bay which, as the name suggests, was a safe haven for ship repair, and the anchorage for storage hulks.

The Museum requested that a halt be made on the dredging adjacent to the wreck, to allow for an investigation of the site to be carried out. The Commonwealth Department of Works (under whose authority the dredging work was being done) agreed to the request but with the proviso that delays to their work be kept to a minimum.

Under the supervision of Museum staff, the vessel was moved into a specially prepared trench, so that it lay below the datum to which the area was being dredged (Figs 2 and 3).

As the Museum was already fully committed to other archaeological programmes, the task of identifying the wreck was given to the Association.

The Association organized three teams for the project: one team handled archival research and the drawing up of measurements and material recovered; whilst the other two groups operated on alternate days of the weekend, conducting the on-site excavation and measurement.

Initial investigation

A search of local shipping records and contemporary accounts revealed at first that there were only eight vessels whose remains were thought to be in the vicinity of Careening Bay. The relevant details are as follows:

i *Rockingham* (427 tons). Abandoned 1830. Ship rigged. This vessel was stripped of her rudder gudgeons and copper sheathing in 1880 after lying derelict in the bay for about 50 years.

ii *Dato* (200 tons). The remains of this small brig were located upside down in the bay in 15 m of water.

iii *August Tellefson* (400 tons). Abandoned 1898. Three-masted barque, built in Norway.

iv *Annie Lisle* (347 tons). Three-masted barque. Length 40·5 m, beam 8·0 m, depth 3·8 m. Built in Quebec and used in Careening Bay as a coal hulk. Abandoned after 1889.

v *Harrison* (384 tons). North American registered. Three-masted schooner. Was used as

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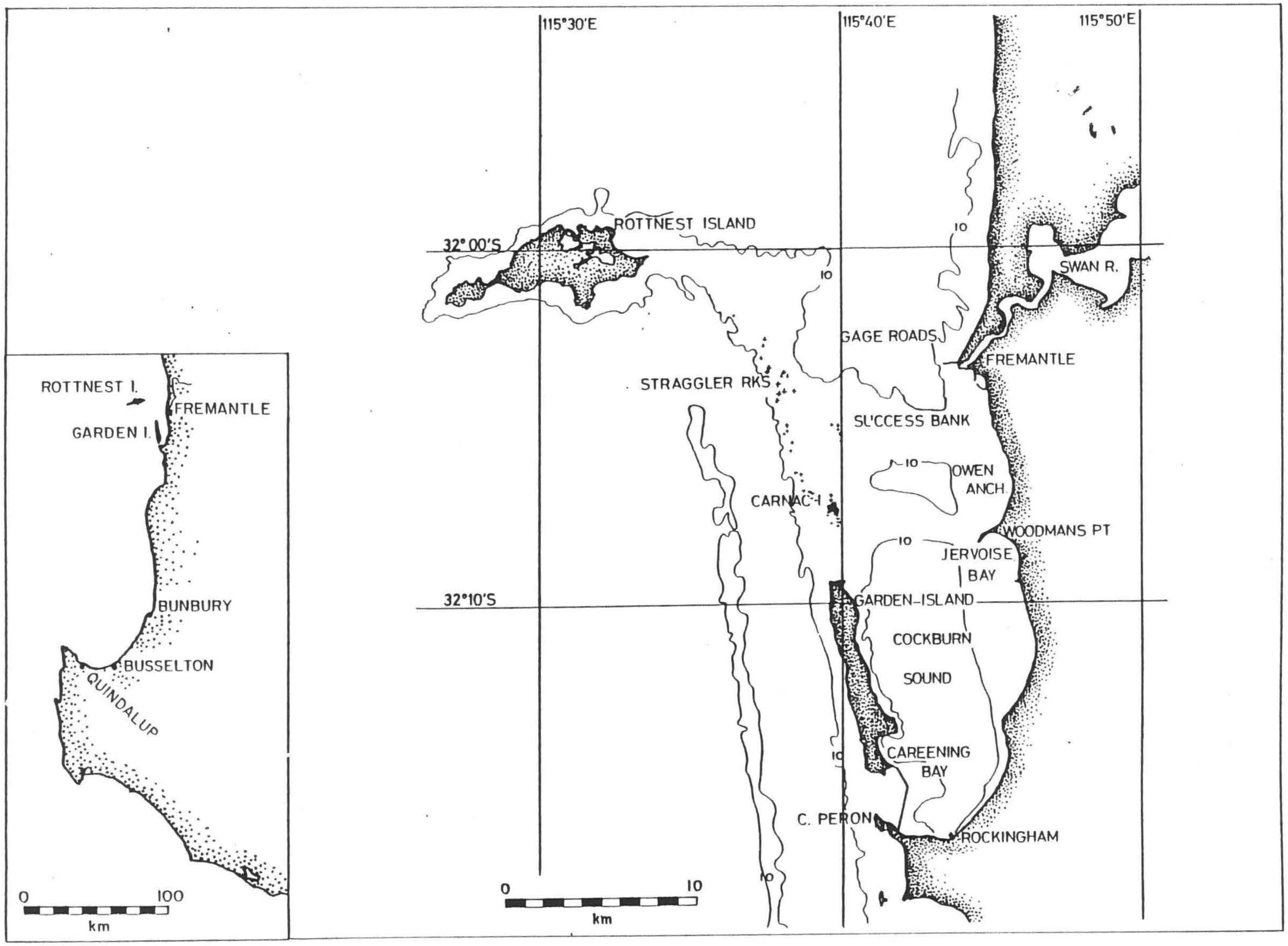

Figure 1. Chart of port of Fremantle and Cockburn Sound showing the *Day Dawn* wreck site. Inset, map of south-west of Western Australia.

a hulk in the bay till 1910, when it was abandoned.

vi *Runnymede* (720 tons). Wooden ship. Length 47·5 m, beam 8·8 m, depth 5·9 m. Built in Sunderland, UK in 1854. Hulked after 1865. She had yellow metal sheathing with copper or brass (?) fastenings.

vii *Redemptora* (1250 tons). A wooden ship. Built around 1853 in the USA. Abandoned in the 1880s.

viii *St. Lawrence* (1019 tons). Wooden ship. Length 54·5 m, beam 11·4 m, depth 6·5 m. Built in Newcastle, UK in 1861. She was sheathed in yellow metal and had copper and brass fastenings.

The initial inspection was conducted by Museum and Association divers. The vessel appeared to have been run aground, stripped of everything useful above water level, and then burnt to recover copper fastenings. The remains measured 31 m long with a maximum breadth of approximately 7 m, and depth to the top of the keel of 3 m. The vessel was intact and well-preserved below the waterline. The copper fastenings had Muntz metal washers and she was sheathed in yellow metal, over tarred felt.

The hull was completely buried, except for the charred tops of what remained of the ribs, and the whole length of the starboard side which jutted out from the bank down which the ship had been moved (Fig. 3). The bow section was unrecognizable, and at the stern the rudder and sternpost were severely damaged. Scoring from the dredge cutter was evident along the exposed starboard side, and it appears that after initial contact with the bows, the dredge slid along the wreck and destroyed the stern.

The presence of Muntz metal indicates that the ship was almost certainly built after 1832, the year the metal was invented. The yellow metal (Muntz metal) sheeting signifies a date of sinking post-1846, the year the patent for this was taken out.

Thus, before the excavation had begun, the *Rockingham* and the *Dato* had been eliminated as possibilities, and the British ships *Runnymede* and *St. Lawrence*, along with the *Redemptora*, were obviously too big as the smallest was 47·5 m long while the site was only 31 m long in the area of the waterline.

This left three known vessels as possibilities: the two American-built ships *August Tellefson* and *Harrison*, and the *Annie-Lisle*.

The task remained to excavate the site in order to gain further information, and to take measurements that might be useful for comparison, with plans or specifications in the written records.

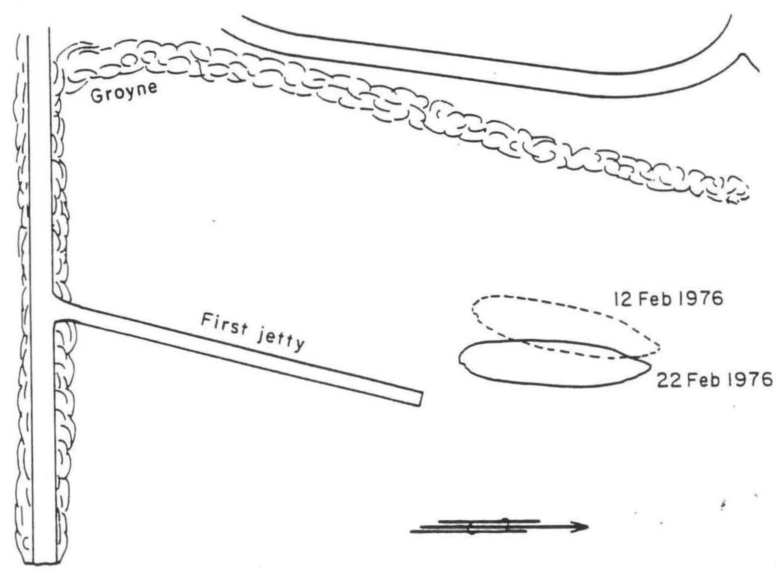

Figure 2. Careening Bay Wreck, position in small boats harbour before and after relocation. (Drawing: Scott Sledge).

The excavation of the site – (Commenced 4 April 1976)

Equipment was usually available to the Association from the Museum, but on this occasion it was not possible, and the Association arranged for the hire and construction of its own equipment with funds supplied by the Museum.

A low pressure air compressor (1800 litres per minute) was hired to power the airlift; this was set up with the other equipment on the beach adjacent to the site. The compressor was connected to a 0·15 m diameter airlift by means of a flexible 0·025 m diameter hose from the shore to the site. The airlift was connected to a 0·15 m PVC pipe which hung over the starboard side of the wreck, and was anchored to the bottom in such a way as to deposit the spoil 10 m to the seaward side of the wreck.

A second airlift was later fitted to the compressor, and despite a slight drop in suction, this proved to be efficient, and effectively

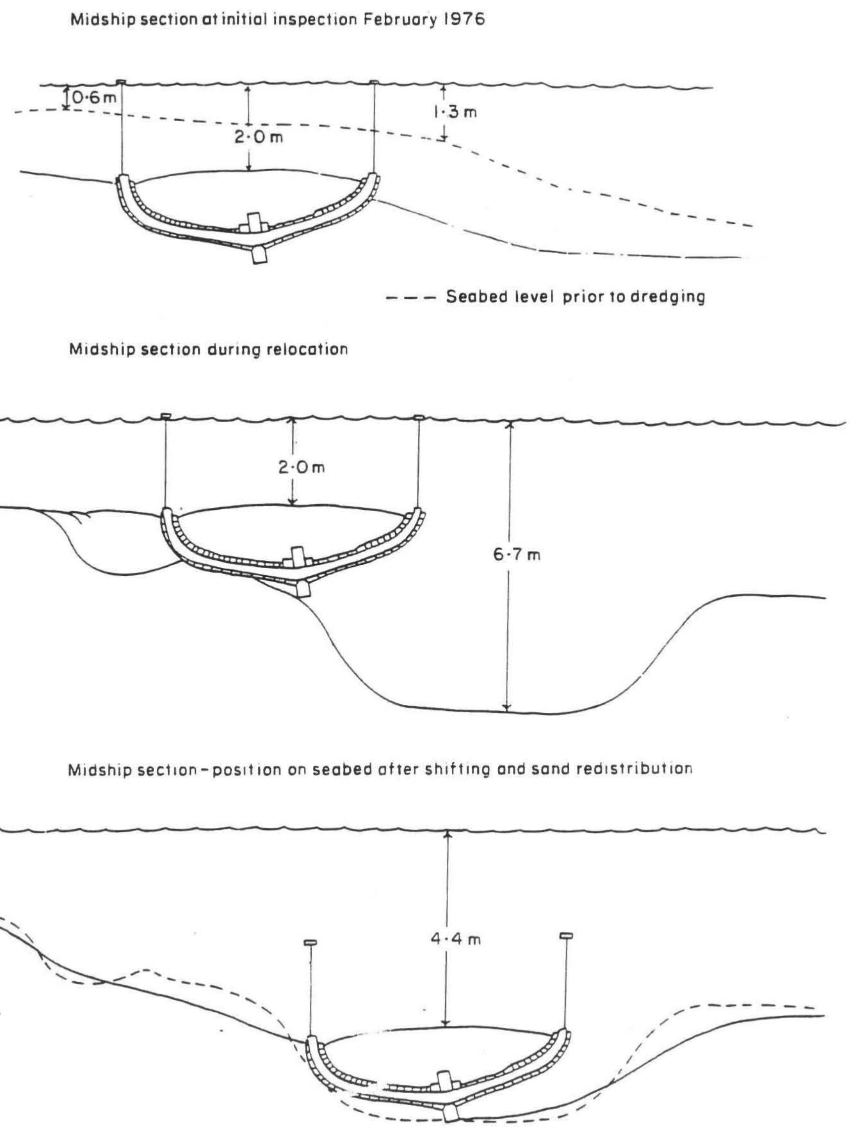

Figure 3. Sequence showing dredging operation to re-locate wreck. Upper as at initial inspection, middle during operation, lower at end of operation. (Drawing: Scott Sledge and Myra Stanbury.)

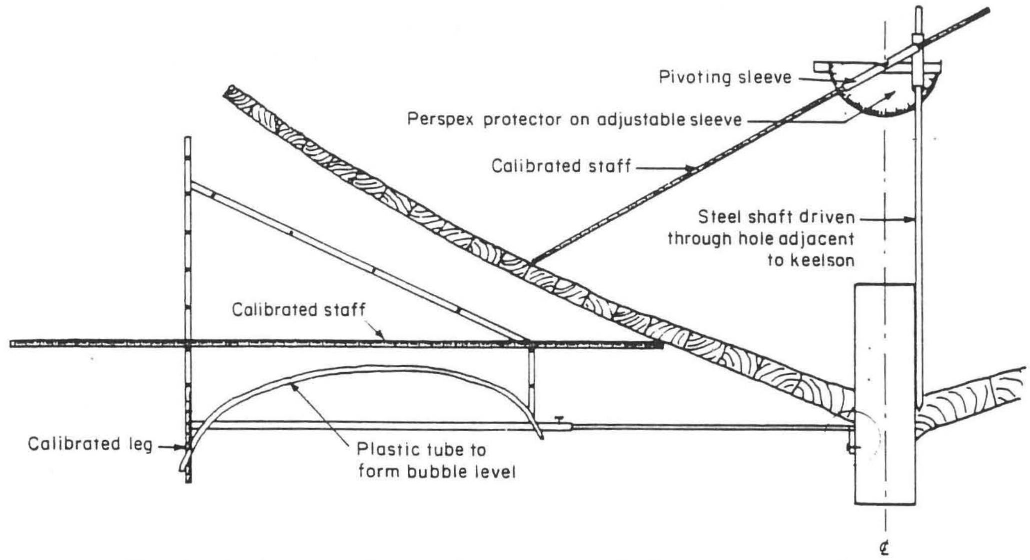

Figure 4. Plan showing internal and external contour measuring instruments. (Drawing: Ron Stevens.)

doubled the amount of spoil removed from the site. A close watch was kept by the airlift operators to prevent any artefacts being sucked into the inlets. It was not until the sixth working day that any artefacts were uncovered, and by this time the whole of the starboard side had been cleared to a depth of 1 m and width of 3 m.

Even though the excavation had now moved into the artefact layer, diving attendance did not vary much from the average overall turnout of five divers (maximum of eight and a minimum of two). At this point charred timbers appeared in the excavation area. A careful watch was kept to locate structure or anything that would help identify the ship.

Ten working days and a total of about 250 man-hours were spent excavating the inside of the hull, at which point the keelson was just visible, together with a layer of debris and spoil, varying in thickness from approximately 0·05 m near the upper parts of the ribs to about 0·30 m alongside the keelson.

One of the problems experienced early on in the diving operation was a lack of continuity between the two teams of divers. Few, if any, members were able to give more than one day per week to the excavation, which was conducted solely at weekends, when all members were available. This factor lead to an inevitable loss of time and continuity. To resolve this problem and for security reasons, some members remained overnight and handed over to the new team on the following day.

With large scale excavation of the spoil out of the vessel complete, work began on photography and the mapping of the lines and cross-sections of the ship. The resulting plan could then be checked against the original plans, if any existed, that may be located.

To facilitate the mapping of the internal contours, it was planned to cut trenches along the ribs. Initially a water dredge driven by a 7 hp Honda High Pressure Water Pump was used. This was found to be too slow, and unnecessary in view of the lack of artefacts. A small airlift was therefore substituted. An 0·08 m diameter PVC pipe was used to remove the spoil and air was supplied through a nozzle connected to the same hookah lines from which the divers were breathing. Although it occasionally caused a restricted air supply, this system proved to be so efficient and simple that it was used for the remainder of the work. With planks thus exposed from the tops of the ribs to the keelson, the internal contours were taken using an instrument (Figs. 4 and 5) that was devised and constructed by the project leader, Lindsay Hill. One of its most commendable features was its simplicity of construction

and operation. The external contours were taken outside the ship along the same rib lines as the internal contours, using a frame that was set up against the exposed starboard side. The design of this instrument was such that the operators did not have to risk themselves under the ship and, like the internal contour gauge, it could be operated by just one diver (Fig. 4). The results of the external and internal contour measurements is shown in Fig. 6.

A survey was also made of bolt hole diameters, timber sizes and the distance between nail centres, however, no consistent metric or imperial pattern emerged. An attempt to measure the hull thickness using brace and bit proved too time consuming and was restricted to one test hole.

A check was made to see if the keelson was distorted, by running a taut line from stem to stern and reading off the mid points of the

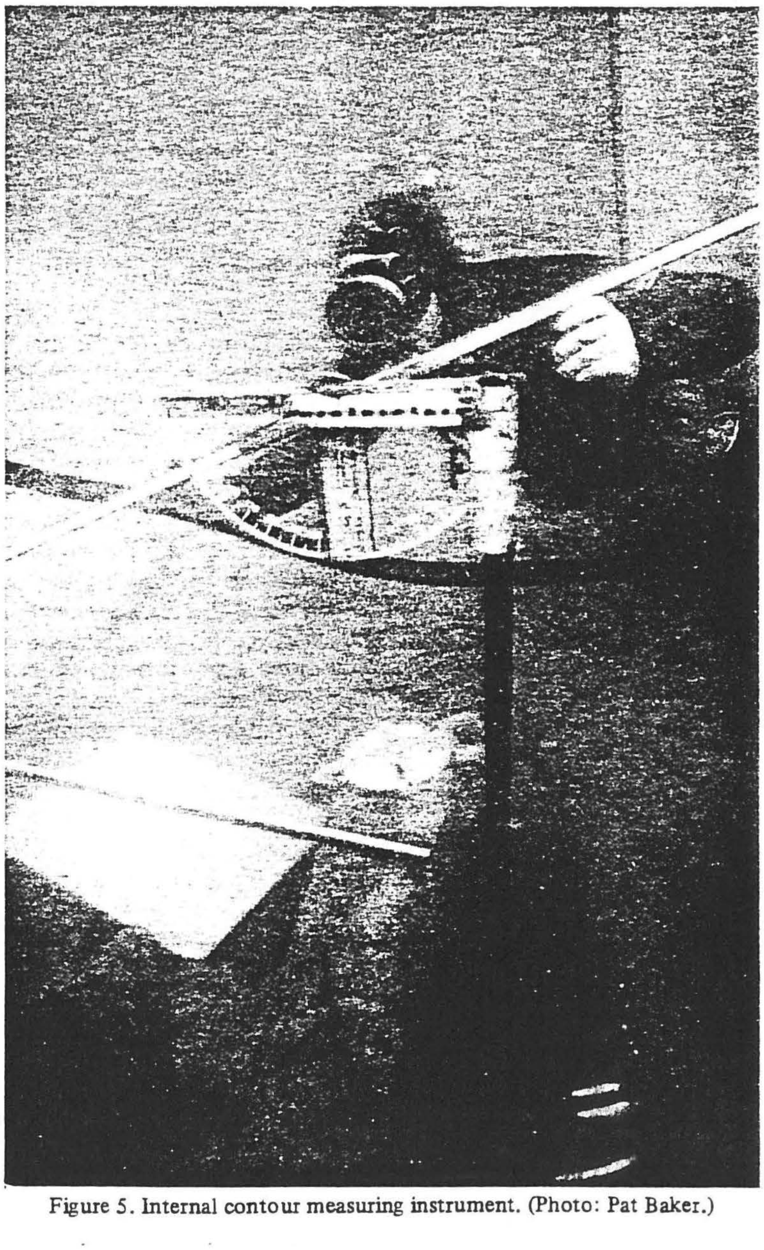

Figure 5. Internal contour measuring instrument. (Photo: Pat Baker.)

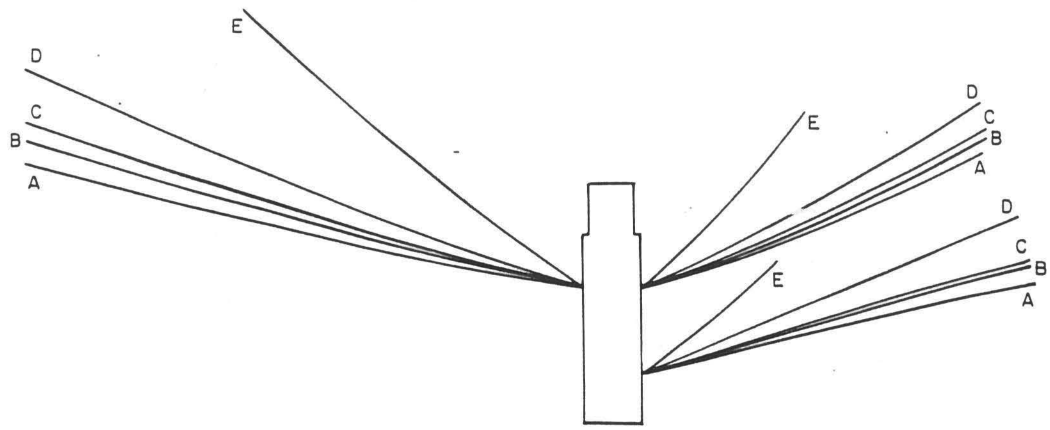

Figure 6. Internal and external contours at frames sections A to E, shown on Fig. 10. (Drawing: Ron Stevens.)

keelson with the line. Three mast steps were uncovered, with two other indentations, possibly deck stanchion sockets. A diagram of the keelson, with the mast steps and the other indentations (Fig. 7), shows that they are all of different sizes. On the final dive, the keel was also measured at various intervals, though the divers involved had to lie under the hull, clear the area with the airlift and feel in the zero visibility for the sections to be measured. During this operation, a gap was noted between the keel and the garboard strake in one section near the stern. Measurements of this were not taken due to the obvious dangers.

A well-preserved capstan was found early in the excavation. As work progressed, loose twigs and small branches were found, along with four jarrah (West Australian wood) planks 2 m x 0·18 m x 0·03 m with the name *Day Dawn* burnt into them (Fig. 8). A bottle dated 1874, a fairlead (wooden rigging block) and two timber railway sleepers in 'good' condition were also excavated along with a mass of unburnt timber which seems to indicate that this area was underwater when the ship was burnt. An iron staple (Fig. 9) and an iron hanging deck knee were also found. These items were part of the deck supporting system and had charred timber loosely attached to them. More significantly the staple knee was of a type used to separate and support two decks. The position of these and other artefacts were marked (Fig. 10) after which they were raised and sent to the museum's conservation laboratory for conservation and cataloguing.

The capstan was raised using the Museum workboat *Henrietta*, and was then handed over to the Association for restoration and cleaning. On removal of the concretion adhering to it, the words D. A. Taylor, Boston were found cast onto the side of it.

Further dives were undertaken to re-check measurements and to take samples from the hull. These samples were sent, together with the branches found earlier, to the Commonwealth Scientific & Industrial Research Organization (Wood Quality Group) for analysis. They were found to contain pitch pine, an American wood, along with oak and elm that could have been either American or European in origin, while the loose branches were of a species found in the Pacific area. The project was closed on 12 June 1977, sixteen months after it commenced, with twenty-four full working days and a total of more than 500 man-hours actually spent on site.

Summary and tentative identification

It seemed from the evidence revealed by the excavation that the ship was a two-decked, three-masted vessel of slightly more than 31 m in length. She had been built in America, probably near Boston, some time after 1832 and had been scrapped after 1846. That she was probably engaged in the local timber trade is evidenced by the jarrah sleepers on board, and was likely to have been on the Pacific coast where she acquired the loose timber indigenous to that region. Coal was not evident in the bilges and therefore, she does not seem to

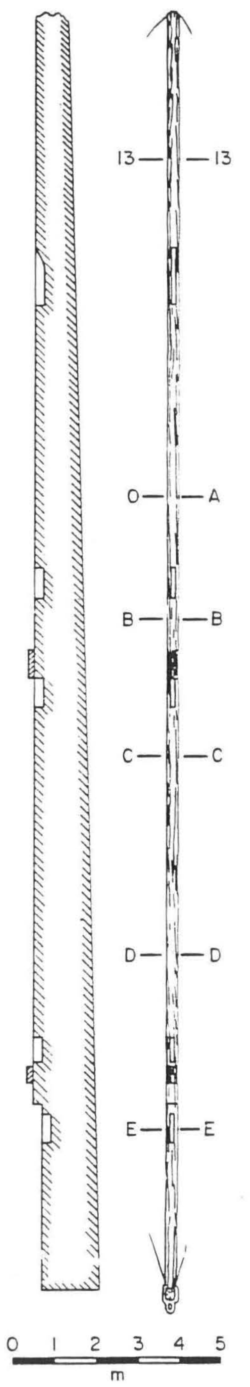

Figure 7. Plan of keelson, showing mast step and staunchion sockets. (Drawing: Ron Stevens.)

have been used as a coal hulk. The general lack of artefacts seems to indicate she was cleaned out and could have been a general purpose hulk. The timber samples together with the capstan, left no doubt as to the American origin of the wreck, thus positively eliminating the Norwegian built *August Tellefson* as a contender. The only possibilities left were the *Harrison* and the *Annie Lisle.*

The last remaining clue was the timber marked *Day Dawn.*

It was initially believed that this may have had some connection with the now abandoned Gold Mining Town of Day Dawn in the Murchison district of Western Australia. Records might show which of the two vessels was involved in trade from there. However, this investigation proved fruitless.

Further research was instigated on the off-chance that there may have been a vessel of that name operating on the Western Australian coast. The records revealed that there was a vessel of that name wrecked in 1886 at Quindalup, near Bunbury, in the south-west of Western Australia (Fig. 1).

Despite an intensive search of local shipping records and contemporary newspapers, the Association has failed to unearth an account of the vessel being moved north to Careening Bay. However, the timber samples, overall dimensions, the Boston capstan and other significant features of the site, indicated that the wreck was almost certainly the *Day Dawn.*

Her details are as follows:

Barque Day Dawn, Ex Thomas Nye *whaler*
Built. Fairhaven, Massachusetts (near Boston)
Launched. June 1851.
Early career. Sailed July 1851, and after completing three successful whaling voyages, was sold in 1862 to H. A. Pierce, a prominant Boston merchant ship owner. She then left New Bedford where she was registered, and disappears from the shipping records kept there. She re-appears in American Lloyds Universal Register of Shipping 1867 under the name *Day Dawn* belonging to the Port of Sydney, New South Wales; her owner P. Jones. She is registered in *Bureau Veritas* of 1872 again as the *Day Dawn*, registered in Sydney; her new owner – H. Barne, Master Captain Sustenance. In 1874, she appears registered under the ownership of James Smith and appears in

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Figure 8. Section of timber with name *Day Dawn* burnt into it. Scale in cm.

the *Register of British Ships in Adelaide* (1877) as sold to Hansford Ward of Yatala, South Australia, Master Mariner. She appears in *The Record* of 1878 of New York again as the *Day Dawn*; her owner H. Ward. She is again mentioned in the 1885 *Bureau Veritas* but had been converted to one deck with two sets of deck beams, her owner and master H. Ward. The Port of Registry in both cases being Adelaide, South Australia

Number. 46469

Rig. 3-masted ship converted to barque rig in 1864

Construction details. Square stern, no galleries, billet head carvel built

No. of decks. Two decks 1872. One deck with two sets of deck beams 1885

Dimensions. 355 tons (Lloyds). 36·9 x 8·5 x 4·35 m

Registered. 1872 Sydney. 1878 on. Adelaide

Materials. Oak, pitch pine and fir. Copper and iron fastenings. Yellow metal sheathing

Later career. The career of the *Day Dawn* is well documented from 1884 onwards and a copy of *Arrivals and Departures* (Fremantle) 1881 to 1900 shows she left Mauritius in 1884 and arrived at Fremantle 'seeking' a cargo. She then made a number of trips, one to Quindalup near Busselton, Western Australia, and another to Adelaide. She returned to Quindalup where she was wrecked on 14 August 1886 while loading sleepers for the Silverton Railway in South Australia. According to the *Adelaide Observer* of 28 August 1885 she was the '... best wooden vessel in the colonies ... strong, tight and sailed remarkably well'. It appears from the article that she went ashore on a long shelving rocky bottom. She was last reported as 'lying on her bilge, hogged, with 40 ft of her keel gone and full of water'. The wreck was sold for £140. It was 14 miles to the nearest Telegraph station at Vasse (Busselton) and on arrival there the crew was paid off and went on to Fremantle.

Excerpts of the above-mentioned shipping records will appear in the Association's major report on the project along with copies of C.S.I.R.O. timber analyses, details of techniques and equipment used, the survey of local residents, a catalogue of material recovered and all other relevant information.

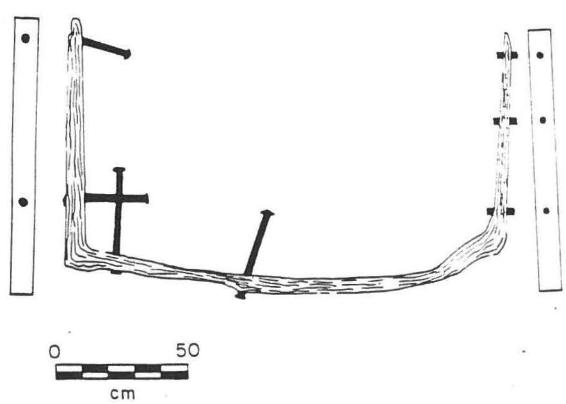

Figure 9. Iron staple knee CB1696, indicating vessel was two decked.

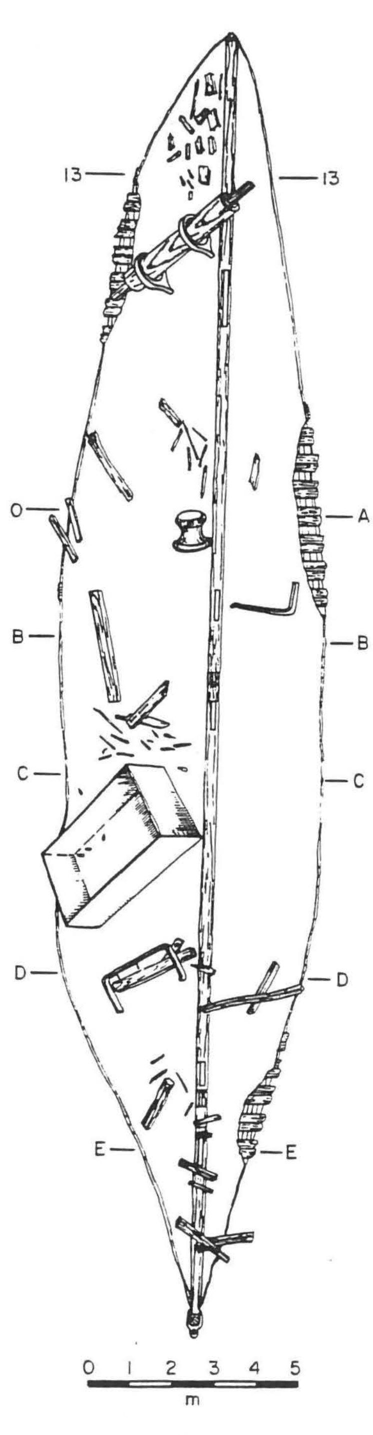

Figure 10. Sketch plan of wreck site, showing significant features and artefacts. (Drawing: Ron Stevens.)

Evidence in support of Day Dawn

1. The timber marked with the name *Day Dawn.* Probably used to hold cargo or more likely to enable her Master to convert her easily from one to two decks. Her deck beams were retained when she was converted prior to 1885 (see specifications) and it would seem a logical step to make such provision and to mark the temporary timbers with the ship's name. Ward is known to have been 'seeking' cargo and it is distinctly possible that he would have been prepared to switch from one deck to two depending on the nature of the cargo sought.
2. The capstan was manufactured in Boston near Fairhaven where the *Thomas Nye* was built, and was possibly too badly damaged by immersion when the *Day Dawn* was wrecked to warrant its salvage when the ship was eventually scrapped. The *Harrison* was built in Quebec and is less likely to have carried a capstan manufactured in Boston.
3. The sleepers (reported in the Field Notes to be in 'new condition') would have been removed from a hulk about to be scrapped unless they were jammed in the bilges with other items. They were probably on board the vessel originally and were reported loaded at the time of the wreck. The *Harrison* also carried timber but it probably would have been removed before she became a hulk.
4. The materials used in the construction and sheathing of the wreck and the *Day Dawn* tally closely with the CSIRO Report which shows that the wood samples were elm, oak, pitch pine, and a species of wood occurring in the Pacific area; the last item appeared in the form of twigs and small branches and could have been firewood or dunnage left in the bilges. The *Day Dawn* was registered in Sydney for a number of years after 1867, and it is quite possible that she shipped this wood on one of her voyages from that port.
5. The coast on which the *Day Dawn* was wrecked in 1886, is reported in the account of the wreck to be 'long and shelving', leaving the distinct possibility for repairs and refloating. The relatively high price of

£140 paid for the wreck, in view of its cargo being of such little value and the fact that she was considered the 'best wooden vessel in the Colonies, strong, tight and sailed remarkably well', makes for fairly promising possibilities of the wreck being salvaged.

6. Quindalup was 14 miles from the nearest large settlement and even further from a ready market for a hulk or ships fittings. If at all possible, the removal of the wreck to Careening Bay, with its facilities and ready market, would mean a higher price for any salvage, and comparatively small transport and labour costs.
7. It is interesting to note that when the *Dato* went aground at the same place in 1895, she was towed to Careening Bay where she eventually sank. Perhaps the *Day Dawn* had established a precedent in successfully completing the relatively short passage from Quindalup to Careening Bay.
8. The mast steps were all significantly different in design. This could be an indication that each mast was rigged in a different manner to the others; e.g. as a barque in comparison to a three-masted schooner like the *Harrison*, which has a similar rig on all three masts. Unfortunately, we have not enough documentary evidence to support or reject this theory and more research needs to be done on the idea.

The evidence for the wreck site/*Day Dawn* link is quite strong, but there is, however, some evidence to the contrary. This evidence and the Association's reasons for considering it less valid than the arguments linking the wreck with *Day Dawn* are outlined below:

1. There is no apparent evidence of the movement of the vessel from Quindalup to Careening Bay: this may not be too incongruous in that the Vasse area did not boast a newspaper till much later, and the arrival of what may have proven to be a useless wreck possibly did not stir the imaginations of contemporary journalists in Fremantle.
2. There is no apparent record of the *Day Dawn* being used as a hulk: *The Fremantle Shipping Register*, in which such information is recorded, does have omissions, however; the brig *Dato*, for example, was converted to a hulk and it was in that capacity that she probably capsized and sank, yet no record of her appears in the Register. It is also distinctly possible that the *Day Dawn* was condemned on its arrival at the Bay and as such may not have been used as a hulk and would not appear in a Register of 'live' ships.
3. There is some indication of damage to the keel of the vessel, but no apparent major damage as was reported in the account of the wreck. Examination of the port side of the ship is not possible, and it is feasible that if the *Day Dawn* lay on her starboard side at Quindalup then the damage seen just after the wreck could be on the inaccessible port side. The high price paid for the wreck does tend to put some doubt on whether the damage was as bad as it looked.
4. The capstan shows no evidence of charring and the white metal bearings of the capstan do not seem to have been damaged by the heat of the fire, which finally destroyed the vessel. If the ship was stripped before she was burnt, then it is reasonable to assume that all useful and accessible timber would have been recovered, thus reducing the intensity of the blaze. It is also possible that the timber was cut from beneath these useless fittings, allowing them to fall into the bilges, which could have been flooded by this time as the pumps would probably have been removed earlier.
5. Most significantly and the most difficult fact to explain is the one discrepancy between the CSIRO report on the timber samples, and the timbers reportedly used in the *Thomas Nye's* construction. Fir was reportedly used on the ship whereas the CSIRO report shows elm as one of the timbers analysed. Fir was used extensively on ships' decking in North America, and it is quite probable therefore that there is no decking left on the wreck, hence the absence of fir in the sample. The absence of elm in the shipping records is less easy to explain and can only be attributed to a possible omission on the part of the Recorder involved.

These errors of omission are not uncommon and even occurred on other occasions with this vessel. (See *Bureau Veritas* 1872 and 1885 reproduced in the Association's detailed report due to be published in book form.)

Conclusions

1. Had the Association not found the timber marked *Day Dawn*, it is fairly certain that a tentative identification of the wreck site as the *Harrison* or *Annie Lisle* would have been made.
2. Such a hypothesis could not have been proved; however, a further search for more concrete evidence e.g. plans and specification would have been required.
3. Local shipping records cannot be relied upon to provide a complete list of vessels scrapped or hulked in the area. It is evident that condemned ships or hulks were able to enter or leave the local authority's area without appearing on the records. Further projects along similar lines to the *Day Dawn* investigation have been commenced this year (1978), and in view of the *Day Dawn* experience all projects must be prepared to include vessels wrecked further afield in their lists of possibilities for identification.
4. There may be great value in a study of mast steps as an aid to vessel identification e.g. the difference, if any, in the mast steps of a three-masted barque, ship or schooner.

The future of the wreck

Moves have been made to re-bury the wreck so as to ensure its preservation for future generations. As yet, attempts to raise finance for the project have been unsuccessful. The Association and Museum will continue in their efforts to have the vessel covered, and hope to enlist the help of the contractors whose dredge discovered the wreck.

Acknowledgements

Drawings: Ron Stevens, Scott Sledge and Myra Stanbury.
Research: Mike Pollard and Scott Sledge.
Photography: Pat Baker.

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French summary

Fouille et identification du baleinier *Day Dawn* (Australie Occidentale)

MIKE McCARTHY

Cette étude illustre un nouveau procédé permettant de relever les contours intérieurs et extérieurs d'un bateau. Cette méthode a été appliquée sur un bateau construit en 1851 et naufragé sur la côte ouest d'Australie.

United States Department of the Interior
NATIONAL PARK SERVICE
GOLDEN GATE NATIONAL RECREATION AREA
FORT MASON, SAN FRANCISCO, CALIFORNIA 94123

IN REPLY REFER TO:

H3015 (WR-GOGA)

March 10, 1983

Memorandum

To: General Superintendent

From: Historian

Subject: Recovered Shipwreck Material from Rodeo Beach

The most recent winter storm to hit the San Francisco Bay area uncovered the partial remains of a shipwrecked vessel on the beach at Rodeo Lagoon. Park maintenance staff engaged in cleaning debris from the beach after the storm were notified by visitors on Wednesday, March 2 that a piece of ship wreckage was visible in the surf just north of Rodeo Lagoon footbridge. Maintenance worker Lory Lacsamana accompanied one of the visitors to the area where two other park visitors were observed removing copper fastenings from the piece of wreckage. As the wreckage was left exposed by retreating high tides, Lacsamana and his fellow workers removed the piece to the Marin Headlands Roads and Trails maintenance yard.

On Thursday, March 3, I was notified of the discovery by District Ranger Bob Cheung and was asked to identify the wreckage. Accordingly, on Friday March 4, both myself and Archaeologist Martin Mayer went to the maintenance yard to see the piece of wreckage. The piece was photographed and detailed scale drawings were prepared by Mayer (Attachment #1). Our preliminary assessment of the remains revealed two pieces of outer hull planking with the stubs of copper sheathing nails imbedded in the wood. This, and the shape and configuration of the remains, led us to believe the piece was from the stern of the vessel. This preliminary identification was confirmed later with the consultation of an illustrated encyclopedia of marine construction (See Attachment #2). What was recovered was the sternson, inner post, and fragments of outer hull planking from a fair size vessel (approximately one hundred feet long) of the nineteenth century.

The dimensions of the timbers were approximately the same as like timbers in the stern of the <u>Niantic</u>, a 119 foot long vessel. Since the timbers were entirely fastened with yellow metal (an alloy of copper close to brass) we feel that the date of construction falls between 1850-1870. Of course, yellow metal was used in quality ships up to around 1880 and was used for decades prior to 1850; we have merely selected median dates. The timber used in the construction appears to be oak; we anticipate removing samples of the

wood for analysis by the University of California's Forest Products Laboratory in Richmond. One side of the piece recovered was badly eaten by teredo navalis and one dead worm was removed from the timber. This would indicate that this piece was at least partially buried, with the exposed portion being infested by teredo worms. If the piece recovered had floated in the water for some time, or had it been lodged in an exposed place on a rocky shoreline, it would have been completely consumed. Therefore, it seems likely that this piece was either deposited on the beach soon after the wreck of the vessel, having drifted in from some other location, or it is a part of a vessel which wrecked at Rodeo Beach and only recently became detached from the main body of wreckage from the vessel.

Two vessels are known to have wrecked in the immediate vicinity of the beach. The first was the English ship Jenny Lind in or around 1850; the second was the clipper San Francisco, which was lost on her maiden voyage from New York to San Francisco in 1854. It is improbable that we will be able to determine if the wreckage comes from either ship. Since the prevailing current sweeps north along the Marin shoreline, it is possible that the wreckage could have been swept in from a shipwreck farther south, perhaps even at the Golden Gate. A careful walking survey of the beach, incidently, was performed and no additional wreckage of shipwreck materials were noted. Either they are not present or are buried deeper in the sand. Visitors to the beach have stated that a smaller piece of wreckage, perhaps a knee (deck beam support) was seen on the beach about a year ago, and unconfirmed reports of Spanish coins, one dating to the sixteenth century, on the beach, have also reached us. The Spanish coins, incidently, do not necessarily indicate that a galleon ran aground here; the coins were in use throughout the world for centuries and were a common coin in Gold Rush California. Spanish and foreign currency was in use here until the establishment of the mint in 1854.

Due to the lack of associated materials or the evidence of a more complete shipwreck, we feel that the removal of the piece from the beach by the maintenance crew was a proper action, particularly considering the removal of some of the yellow metal fastenings by visitors. It is likely that the piece would have been destroyed, removed, or left exposed and subjected to destruction by teredo navalis. Lacsamana and his colleagues are to be congratulated. The piece in question was taken to Building 315, Fort Mason, for integration into the park's museum collection after our recording work was completed by Lacsamana. Should the piece be eventually traced to a known historic wreck, it will then be accessible. Meanwhile, we have recorded and saved yet another fragment of nineteenth century marine construction and furthered our knowledge of the Golden Gate National Recreation Area's rich maritime archaeological resources.

If you approve, we shall from time to time perform brief walking surveys of Rodeo Beach to see if any additional materials surface. If a complete wreck is found, a management decision could be made at that time concerning the nature and scope of work required to document and evaluate it. Meanwhile, thank you for the opportunity to deal with these endangered cultural resources.

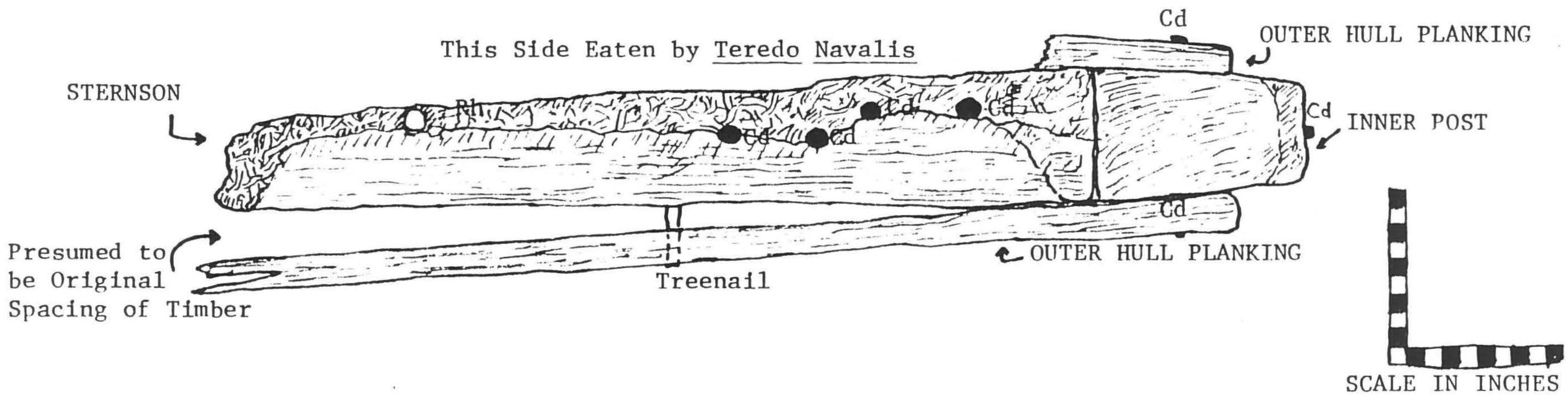
LEGEND

Copper Drift Cd

Round Hole Rh

TOP VIEW OF
SHIP WRECKAGE FROM RODEO LAGOON BEACH
GOLDEN GATE NATIONAL RECREATION AREA
MARIN COUNTY, CALIFORNIA
March 4, 1983

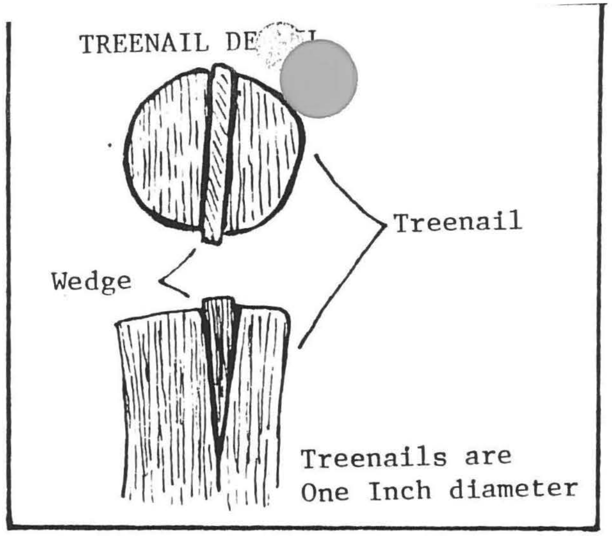
Based on an Original Drawing by
Martin T. Mayer



Side View Drawing of This Piece Shows Longest Section of
Outer Hull Planking and Does Not Reflect Teredo Damaged Area.

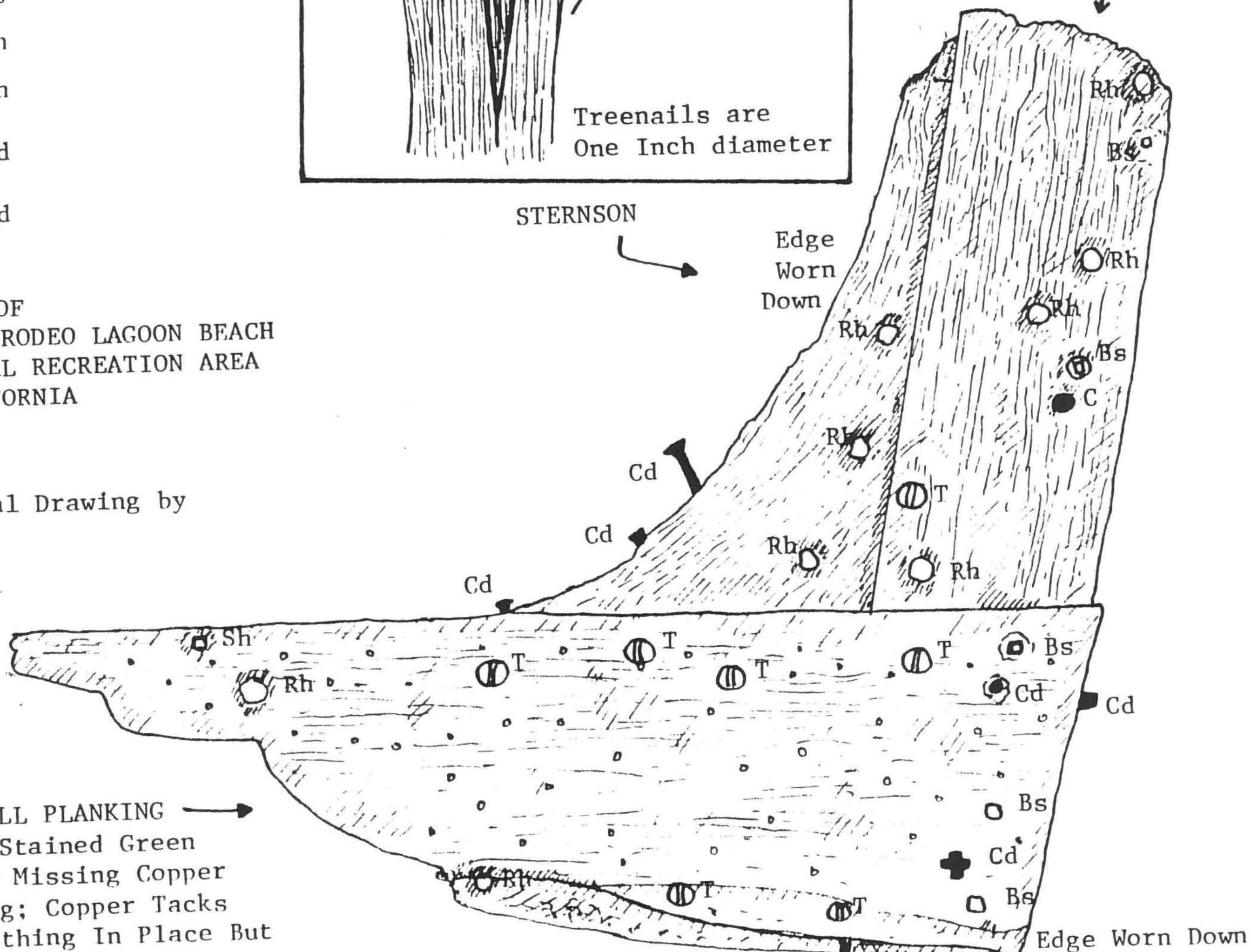
LEGEND

Treenail		T
Copper Drift		Cd
Brass Spike		Bs
Round Hole		Rh
Square Hole		Sh
Brass Drift		Bd
Copper Drift		Cd

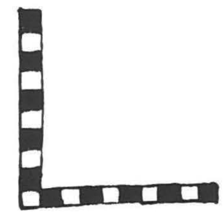


SIDE VIEW OF
SHIP WRECKAGE FROM RODEO LAGOON BEACH
GOLDEN GATE NATIONAL RECREATION AREA
MARIN COUNTY, CALIFORNIA
March 4, 1983

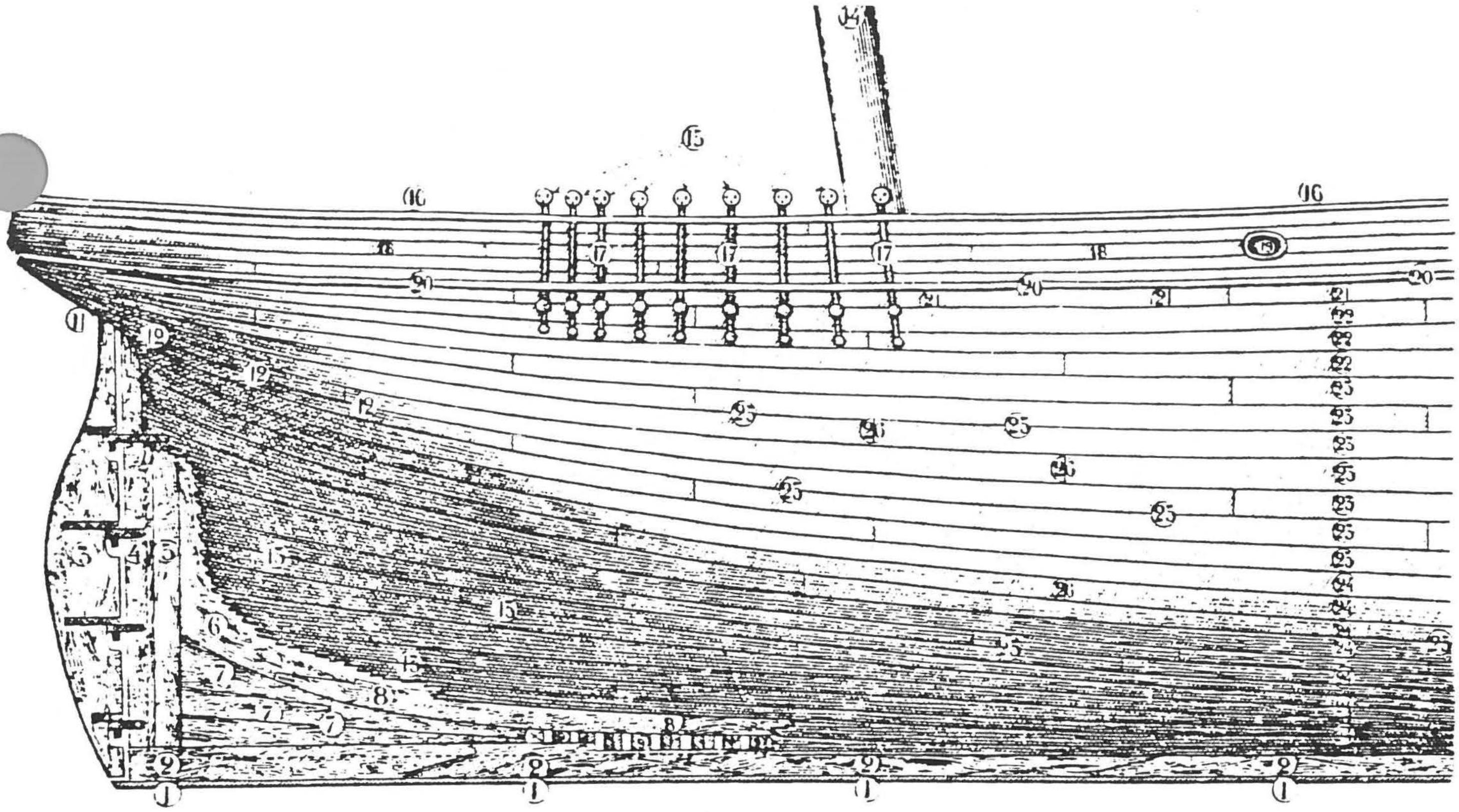
Based on an Original Drawing by
Martin T. Mayer



OUTER HULL PLANKING
Surface Stained Green
From Now Missing Copper
Sheathing; Copper Tacks
For Sheathing In Place But
Missing Heads.
Plank 2" x 13"



SCALE IN INCHES



After portion of a Wooden Vessel, planked.

1 False-keel.

2 Keel.

3 Rudder.

4 Stern-post.

5 Inner-post.

6 Sternson.

7 Dead-wood.

8 Keelson.

9 Floors.

10 Stern; Upper-stern.

11 Counter; Lower-stern.

12 Buttock.

13 Run.

SOURCE: Capt. H. Paasch, Illustrated Marine Encyclopedia. (1889) Note Items Number 5 "Inner-Post" and Number 6 "Sternson" on the Drawing. This is believed to be the nature of the shipwreck remains recovered from the Rodeo Lagoon Beach.